THE

ENGINEER'S AND MECHANIC'S

NCYCLOPÆDIA,

COMPREHENDING

PRACTICAL ILLUSTRATIONS

OF

THE MACHINERY

AND

CESSES EMPLOYED IN EVERY DESCRIPTION OF MANUFACTURE

OF THE

BRITISH EMPIRE.

With nearly Two Thousand Engravings.

BY LUKE HEBERT,

CIVIL ENGINEER,

DITOR OF THE HISTORY AND PROGRESS OF THE STEAM ENGINE, REGISTER OF ARTS, AND JOURNAL OF PATENT INVENTIONS, ETC.

IN TWO VOLUMES.

VOL. II.

"How much useful knowledge is lost by the scattered forms in which it is ushered to the world! How many solitary students spend half their lives in making discoveries which had been perfected a century before their time, for want of a condensed exhibition of what is known!"—BUFFON

LONDON:

THOMAS KELLY, 17, PATERNOSTER ROW.

MDCCCXLVI.

THE

ENGINEER'S AND MECHANIC'S

ENCYCLOPÆDIA.

ISINGLASS. A solid glutinous substance, almost wholly gelatine, prepared chiefly from a fish of the sturgeon kind, caught in rivers of Russia and Hungary. The belluga yields the greatest quantity, as being the largest and most plentiful fish in the rivers of Russia; but the sounds, or air bladders of all fresh-water fish, yield, more or less, fine isinglass, particularly the smaller sorts, found in prodigious quantities in the Caspian Sea, and several hundred miles beyond Astracan, in the Wolga, Yaik, Don, and even as far as Siberia. The following is the usual mode of preparing isinglass:—The sounds, or other parts of which it is to be made, are taken from the fish while sweet and fresh, slit open, washed from their slimy sordes, divested of every thin membrane which envelopes the sound, and then exposed, to stiffen a little in the air. In this state they are formed into rolls, about the thickness of a finger, and in length according to the intended size of the staple: a thin membrane is generally selected for the centre of the roll, round which the rest are folded alternately, and about half an inch of each extremity of the roll is turned inwards. The due dimensions being thus obtained, the two ends of what is called short staple are pinned together with a small wooden peg; the middle of the roll is then pressed a little downwards, which gives it the resemblance of a heart-shape; and thus it is laid on boards, or hung up in the air to dry. The sounds which compose the long staple are longer than the former; but the operator lengthens this sort at pleasure, by interfolding the ends of one or more pieces of the sound with each other. The extremities are fastened with a peg like the former, but the middle part of the roll is bent more considerably downwards; and in order to preserve the shape of the three obtuse angles thus formed, a piece of round stick, about a quarter of an inch in diameter, is fastened in each angle with small wooden pegs, in the same manner as the ends. In this state it is permitted to dry long enough to retain its form, when the pegs and sticks are taken out, and the drying completed; lastly, the pieces of isinglass are collocated in rows, by running packthread through the pegholes, for convenience of package and exportation. The common kinds of isinglass, called the "book" and "ordinary staple," are composed of the membranes, which will not admit of a similar formation with the preceding; the pieces, therefore, after their sides are folded inwardly, are bent in the centre in such manner that the opposite sides resemble the cover of a book, from whence its name: a peg being run across the middle, fastens the sides together, and thus it is dried like the former. This sort is interleaved, and the pegs run across the ends, the better to prevent its unfolding. Ichthyocolla, or isinglass, is one of the purest and finest of the animal glues, of no particular smell or taste. Beaten into threads, it dissolves

pretty readily in boiling water or milk, and forms a gelatinous substance, whi yields a mild nutriment, and proves useful, medicinally, in some disorders.

IVORY. The tusk of the male elephant. It is an intermediate substan between bone and horn—hard, solid, white, and capable of taking a goo polish. The finest, whitest, and most compact ivory comes from Ceylon, which it is observed, keeps its colour better, and therefore bears a higher value than the ivory of Guinea. The article is chiefly consumed for the handles of knives, for ornamental utensils, instruments, cases, boxes, balls, combs, dice, slabs for miniature paintings, and an infinity of toys. The coal of ivory is also used in the arts under the denomination of ivory black. The tooth of the sea horse is also called ivory, but from its extreme hardness it is rarely worked but for making artificial teeth, for which purpose it is admirably adapted, on account of the extremely hard steel-like white enamel which covers it. The shavings of ivory procured from the ivory turners, for domestic use, are boiled in water, in the same manner as hartshorn shavings, and form a jelly inferior to none. Any piece of ivory, scraped into shavings, will answer equally well to sending to the turners, which is not always practicable. In the manufac turing of various articles of ivory and bone, a difficulty is experienced on account of their brittleness; they are therefore softened by submitting them to the action of aquafortis for twelve hours, and subsequently, it is said, to the "juice of berries," to preserve the colour. They are thus rendered so soft and pliant, as to take an impression from a dye. They are hardened again by im mersing them in strong vinegar for four or five hours. When ivory is dis coloured, it may be whitened or bleached by steeping it in a strong solution of alum. The ivory should then be covered with cloth, to prevent it from drying too quickly, which renders it liable to split.

Ivory is stained of various colours in the following manner: *Red.*—Take a quarter of a pound of the cuttings of scarlet cloth, half a pound of soft soap; let the soap be well rubbed into the cloth; then put them into an earthen vessel, and pour upon them two quarts of water; afterwards, boil them for a considerable time, which will extract all the colouring matter. The cloth may then be taken from the vessel, and the coloured liquor pressed out. The ivory to be stained is now to be dipped in aquafortis, then in cold water, and from thence into the dye, whilst it is warm, which will stain it of a beautiful red. *Yellow.*—Boil the ivory in a solution of one pound of alum in two quarts of water, then immerse them for half an hour in a liquid prepared by boiling half a pound of turmeric in a gallon of water, until it be reduced to three quarts and afterwards plunge the coloured substance into alum water. *Green.*—The dye bath for this colour is best made of a solution of verdigris in aqua fortis the process, in other respects, may be the same as that described for yellow *Blue.*—Dip the ivory that has been made green into a hot and strong solutio of pearl ashes, which will turn it to a fine blue. *Purple.*—Dissolve one ounc of sal-ammoniac in four ounces of aqua regia, to form the dye: prepare th ivory, as in the yellow, by boiling it in a solution of alum. Ivory may b *silvered* by immersing a slip of ivory in a weak solution of nitrate of silver, an letting it remain till the solution has given to it a deep yellow colour; the take it out, and immerse it in a glass vessel of clear water, and thus expose in water, to the rays of the sun: in about three hours the ivory acquires black colour, but the black surface, on being rubbed, soon becomes changed a brilliant silver.

IVORY PAPER. The properties which render ivory so desirable a subj for the miniature painter and other artists, are the evenness and fineness of grain, its allowing all water colours laid on its surface to be washed out witl soft wet brush, and the facility with which the artist may scrape off the colc from any particular part by means of the point of a knife or other conveni instrument, and thus heighten and add brilliancy to the lights in his painti more expeditiously and efficaciously than can be done in any other way. T objections to ivory are—its high price, the impossibility of obtaining plates ceeding very moderate dimensions, and the coarseness of grain in the larger these; its liability, when thin, to warp by changes of the weather, and

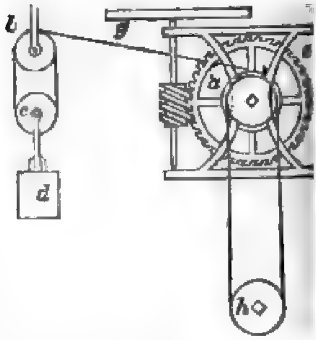
property of turning yellow by long exposure to the light, owing to the oil which it contains. Traces made on the surface of this paper by a hard black lead pencil are much easier effaced by Indian rubber than from common drawing paper, which circumstance, together with the extremely fine lines which its hard and even surface is capable of receiving, peculiarly adapts it for the reception of the most delicate kind of pencil drawings and outlines. The colours laid upon it have a greater brilliancy than when laid upon ivory, owing to the superior whiteness of the ground. Colours on ivory are apt to be injured by the transudation of the animal oil, a defect which the ivory paper is free from. The following is the process given by Mr. Ainslie (of Stratton ground, Westminster,) to the Society of Arts, for which he was voted the sum of thirty guineas. "Take a quarter of a pound of clean parchment cuttings, and put them into a two-quart pan, with nearly as much water as it will hold; boil the mixture gently for four or five hours, adding water from time to time, to supply the place of that driven off by evaporation; then carefully strain the liquor from the dregs through a cloth, and when cold it will form a strong jelly, which may be called size No. 1. Return the dregs of the preceding process into the pan, fill it with water, and again boil it as before, for four or five hours; then strain off the liquor, and call it size No. 2. Take three sheets of drawing paper, (outsides will answer the purpose perfectly well, and being much cheaper are therefore to be preferred,) wet them on both sides with a soft sponge dipped in water, and paste them together with the size No. 2. While they are still wet, lay them on a table, and place them on a smooth slab of writing slate, of a size somewhat smaller than the paper; turn up the edges of the paper, and paste them on the back of the slate, and then allow them to dry gradually; wet, as before, three more sheets of the same kind of paper, and paste them on the others, one at a time; cut off with a knife what projects beyond the edges of the slate, and when the whole has become perfectly dry, wrap a small piece of slate in coarse sand paper, and with this rubber make the surface of the paper quite even and smooth; then paste on an inside sheet, which must be quite free from spots or dirt of any kind, cut off the projecting edges as before, and when dry, rub it with fine glass paper, which will produce a perfectly smooth surface. Now take half a pint of the size No. 1, melt it with a gentle heat, and then stir into it three table spoonsful of fine plaster of Paris; when the mixture is completed, pour it out on the paper, and with a soft wet sponge distribute it as evenly as possible over the surface; then allow the surface to dry slowly, and rub it again with fine glass paper. Lastly, take a few spoonsful of the size No. 1, and mix it with three-fourths its quantity of water; unite the two by a gentle heat, and when the mass has cooled, so as to be in a semi-gelatinous state, pour about one-third of it on the surface of the paper, and spread it evenly with the sponge; when this has dried, pour on another portion, and afterwards the remainder; when the whole has again become dry, rub it over lightly with fine glass-paper, and the process is completed; it may accordingly be cut away from the slab of slate, and is ready for use." The quantity of ingredients above mentioned is sufficient for a piece of paper 17½ by 15½ inches. Plaster of Paris gives a perfectly white surface; oxide of zinc, mixed with plaster of Paris, in the proportion of four parts of the former to three of the latter, gives a tint very near resembling ivory; precipitated carbonate of barytes gives a tint intermediate between the two.

J.

JACK, in Mechanics, a portable machine for raising great weights through a small space. It consists of a rack and pinion inclosed within a strong wooden case, and the power is applied by means of a winch or handle fixed upon the axis of the pinion; the upper end of the rack is formed into two horns, to take

the better hold of the article to be elevated; and from the lower end, two prong project laterally through a longitudinal groove in the case, which are used upo occasions when there is not room to introduce the jack beneath the load. T prevent the labourers being overpowered, there is a ratchet-wheel and pall o the axis of the pinion.

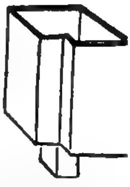
JACK (Kitchen). A machine in which the descent of a weight is made t turn a spit. The ordinary construction is represented in the annexed sketch which may be briefly described as follows:—*a* is a barrel, round which is coiled a line of considerable length; the other end of this line is reeved through two threefold or fourfold pulleys, *a b* and *c*, generally placed against the outside of the house, and at a considerable height, so as to allow the greater range for the weight *d* attached to the lower block *c* to act in. Upon the spindle of the barrel is fixed a pulley *e*, and a similar one is also fitted to the spit *g*, and round these two pulleys passes an endless chain. The weight *d* being sufficient to overcome the friction of the machine, descends slowly, and uncoils the line by turning the barrel round, which causes the spit likewise to revolv To render the motion equal, and to prevent the jerks which would arise in th case of the meat being unequally spitted, so as to act with more force on on side of the spit than on the other, a wheel of about forty teeth is placed on th axis of the barrel, and works into a double threaded screw, placed upon th spindle of the horizontal fly, which thus performs a revolution for every tw teeth of the wheel, or twenty revolutions for one of the barrel *a*, and by th great velocity prevents any alteration in the motion of the barrel. When th weight has descended through its range, it is wound up by a handle which ca be fixed on a square end of the barrel spindle. The Chinese crane would, pe haps, be found a superior arrangement to the treble or fourfold blocks, as th friction is considerably less.



JACK (Smoke). Another contrivance for the same purpose as the forme but acting not by a weight, but by means of the smoke or rarefied air passin up the chimney, which striking against a set of oblique vanes, fixed to a ve tical spindle, causes it to revolve with great rapidity. Upon the spindle is fix a small bevilled wheel working into another small wheel placed upon a horizo tal axis, which has a screw cut upon the other end of it; this screw wor into a wheel on the axis of the pulley that drives the spit: the latter is th carried slowly round. The vanes should be placed in the narrow part of th chimney, where the motion of the smoke is swiftest, and should occupy near the whole space, so as to intercept the greatest part of the current.

JACK IN THE BOX. A large wooden solid screw, turning in a hollow on which forms the upper part of a strong wooden box, shaped like the frustrum a pyramid: it is used by means of levers, passing through holes in it, as press in packing, and for other purposes.

JAMB-POSTS. The side posts of doors. Mr. T. N. Parker having noticed how rapidly the lower ends of door-posts decayed where they are exposed to wet, contrived a cast-iron socket for them, which is much used in Shropshire, and might be generally introduced with advantage. The sketch in the subjoined cut represents one of them beautifully cast by the Colebrook-Dale Company; the weight of them is only 7lbs. the pair, and they are retailed in Oswestry at 2½*d.* the pound. When the increased durability and strength conferred by these metal sockets, to an important part of a building, is considered, the trifling cost will not, we think, form an impediment to their employment.



JAPANNING. The art of painting and varnishing, after the manner originally practised by the natives of Japan, in the East Indies. It is employed for the purpose of preserving and beautifying various articles, usually of wood and metal, as well as of paper, leather, and cloth, when they are properly prepared for the purpose. Those articles we most commonly find japanned, are pieces of household furniture, cabinet work, boxes of all kinds, trays, screens, &c. and, very generally, those articles made of any of the above-mentioned or similar materials, which it may be desired to preserve from moisture; and this it is admirably adapted to effect, from its drying very hard, and being impervious to water at all moderate temperatures, even to boiling in some cases; but it may be employed on any dry substance that is sufficiently inflexible to prevent the japan coating from being cracked or forced off. The true japan, or that said to be used by the natives of Japan and China, is a sort of varnish or lacker peculiar to itself. It is sometimes brought over to this country; but on account of the injury arising from its poisonous qualities, to those persons employed in working with it, is now seldom used. It is the juice of a peculiar tree growing in those parts, and is collected by making an incision into the lower part of the trunk of the tree, and placing vessels underneath to receive it. This juice has the appearance of cream when it first runs from the tree, but on exposure to the air it becomes black. It is prepared for use by submitting it to the action of the open air in shallow vessels, and is kept constantly stirred for many hours, so that by having all parts equally exposed, it may become of a uniform deep black. A portion of well-charred wood reduced to a fine powder is added, and it is then fit for use. The Japanese first spread it thinly and evenly over the body intended to be japanned, and then dry it in the sun. If necessary, another coat is laid on, and dried as before. It very soon becomes harder than most of the substances on which it is laid. As soon as it is sufficiently hard, it is polished with a smooth stone and water, until it becomes as smooth and even as a plate of glass, and then wiping it dry, it is ready to be varnished, except when figures or other ornaments are to be drawn on it in gold or silver: in that case, the form of the figures or other ornaments is to be traced on the work with a pencil, in the varnish noticed below. When this varnish is almost dry, the gold or silver leaf is to be laid on; the whole is then ready to receive the varnish, or finishing coat, which must be spread on thin, and as evenly as possible. This varnish is a particular sort of oil procured in Japan, boiled and mixed with turpentine. When any other colour than black is desired, the proper colour must be mixed with the varnish, and the whole spread on, particular care being taken that it be laid on evenly. The above is the method of japanning said to be practised by the natives of Japan. Our method differs from it considerably; it is less durable, but its practice is not so injurious to the health. We in some cases employ a priming or under coat for the purpose of filling up any inequalities, and making smooth the surface to be japanned; but at other times the priming is altogether omitted, the coloured varnish or proper japan ground bein applied immediately to the substance to be japanned. The former is the method that was usually practised, and still is, in those cases when the surface is very uneven and rough; but when the surface is smooth, as in the case of metals, smooth grained wood, &c. it is now always rejected. The advantage of using the priming or undercoat is, that it makes a saving in the quantity of varnish used, because the matter of which the priming is composed fills up the inequalities in the surface of the body to be varnished, and makes it easy, by means of rubbing and water polishing, to procure an even surface for the varnish. This was, therefore, such a convenience in the case of rough and uneven surfaces, that it became an established method, and is still retained in many instances. There is, however, this inconvenience always attending the use of priming or undercoat of size and whiting, that the japan coats of varnish and colour will be constantly liable to be cracked and peeled off by any violence, and will not endure near so long as the bodies japanned in the same manner, but without the priming. This may be easily observed by comparing those articles that have been some time in wear, especially snuff-boxes, in the

japanning of which the priming has been used, with those in which it has been omitted; the latter never peel or crack, or suffer damage, unless by great violence, and such a continual rubbing as wastes away the substance of the varnish, while the japan coats of the former crack and fly off in flakes, whenever any knock or fall, especially at the edges, exposes them to injury. The Birmingham manufacturers who originally practised the japanning only on metals, to which the reason before stated for the use of priming did not apply, and who took up this art of themselves, as a new thing, of course omitted at first the use of any such undercoat, and not finding it more necessary in the instance of *papier machè* and some other things, than on metals, continue still to reject it; on which account the boxes and other articles of their manufacture are, with regard to the wear, much better than those on which the priming is still used.

Having thus noticed the method originally practised, and the chief variation in the method now employed, we shall pass on to the manner of proceeding with the work to be japanned; the first in order will be the—

Priming.—The priming is a composition of strong size and whiting. The size should be of a consistency between the common double size and glue, and mixed with as much whiting as will give it a good body, so as to hide the surface of whatever it is laid upon. But when the work is of a more particular kind, it is better to employ the glover's or the parchment size, instead of the common, and if about a fourth of isinglass be added it will be still better, and if not laid on too thick, will be much less liable to peel or crack. The work should be prepared for this priming by being well cleaned, and brushed over with hot size, diluted with two-thirds of water, provided it be of common strength; the priming should then be laid on with a brush as evenly as possible, and left to dry. If the surface be tolerably even on which the priming is used, two coats of it laid on in this manner will be sufficient; but if on trial with a wet rag or sponge it will not receive a proper water polish on account of any inequalities not sufficiently filled up, one or more coats must be given it. Previous to the last coat being laid on, the work should be smoothed by rubbing it with the Dutch rushes, or fine glass paper. When the last coat is dry, the water polish should be given, by passing over every part of it with a fine rag or sponge moistened, till the whole appear perfectly plain and even; the priming will then be completed, and the work ready to receive the japan ground, or coloured varnish. But when wood or leather is to be japanned, the latter being first securely stretched on a frame or board, and no priming is used, the best preparation is to lay on two or three coats of coarse varnish, prepared in the following manner: "Take of rectified spirits of wine one pint, and of coarse seed-lac and resin, each two ounces. Dissolve the seed-lac and resin in the spirit, and then strain off the varnish." This varnish, like all others formed of spirits of wine, must be laid on in a warm place, and all dampness should be avoided; for either cold or moisture chills it, and thus prevents its taking proper hold of the substance on which it is laid. When the work is so prepared, or by the priming with the composition of size and whiting before described, the proper japan ground must be laid on.

Japan Grounds.—The proper japan grounds are either such as are formed by the varnish and colour, where the whole is to remain of one simple colour, or by the varnish with or without colour, on which some painting or other decoration is afterwards to be laid. This ground is best formed of shell-lac varnish, and the colour desired; except in the case of white, which requires a peculiar treatment, as we shall presently explain, or when great brightness is required, in which case also other means must be pursued. The following is the composition and manner of preparing the shell-lac varnish:—"Take of the best shell-lac, five ounces; break it into a very coarse powder, and put it into a bottle that will hold about three pints or two quarts; add to it one quart of rectified spirits of wine, and place the bottle in a gentle heat, where it must continue two or three days, but should be frequently well shaken. The gum will then be dissolved, and the solution should be filtered through a flannel bag; and when what will pass through freely is come off, it should be put into

rized bottle, and kept carefully stopped up for use. The bag may be pressed with the hand till the remainder of the fluid be forced out; it be tolerably clear, may be employed for coarser purposes, or kept d to the next quantity that shall be made." Any pigments whatever ed with the shell-lac varnish, which will give the tint of the ground d they may be mixed together to form any compound colours; but, at to such as require peculiar methods for producing them of the of brightness, we shall particularize them below. They should all very smooth in spirits of turpentine, and then mixed with the var- hould be spread over the work very carefully and even with a camel- . As metals never require the priming of size and whiting, the und may be applied immediately to them, without any other prepa- cleaning, except in the instances referred to below.

apan Grounds.—The forming a ground perfectly white, and of the first hardness, has not yet been attained in the art of japanning, as there stances which can be dissolved, so as to form a very hard varnish, have too much colour not to deprave the whiteness. The nearest however, to a perfect white varnish already known, is made by the composition:—"Take flake white, or white-lead, washed and ground e sixth of its weight of starch, and then dried; temper it properly ing with the mastic varnish prepared in the following manner:— ounces of mastic in powder, and put it into a proper bottle, with a pirit of turpentine; let them boil in a gentle heat till the mastic ed, and if there appear to be any foulness, strain off the solution annel." Lay these on the body to be japanned, prepared either with the priming, in the manner as above directed, and then varnish over or six coats of the following varnish:—"Provide any quantity of the lac, and pick out of it all the clearest and whitest grains; take of ac two ounces, and of gum animi three ounces, and dissolve them, iously reduced to a coarse powder, in about a quart of spirit of wine, off the clear varnish." The seed-lac will give a slight tinge to this a; but it cannot be omitted where the varnish is wanted to be hard, ere a softer will answer the end, the proportion may be diminished, crude turpentine added to the gum animi, to take off the brittle- very good varnish entirely free from brittleness may be formed by gum animi in old nut or poppy oil, which must be made to boil en the gum is put into it. The ground of white may be laid on in this d then a coat or two of it may be put over the ground, but it must be d with oil of turpentine before it is used. This, however, is a long ying, and is more liable to injury than the other, from its tenderness.

pan Grounds may be formed of bright Prussian blue, or verditer r with Prussian blue, or of smalt. The colour may be mixed with ac varnish, as before directed, but as the shell-lac will somewhat colour by giving it a yellow tinge, where a bright blue is required, d before directed in the case of white grounds must be pursued.

arlet Japan Ground, vermilion may be used; but its effect is much by glazing it over with carmine or fine lake. If, however, the gree of brightness be required, the white varnish must be used.

ght Yellow Grounds, king's yellow may be used, and the effect will be d by dissolving powdered turmeric root in the spirit of wine, of which or polishing coat is made, which spirit of wine must be strained from gs before the seed-lac be added to it to form the varnish. The seed- is not equally injurious here, as in the case of some other colours, eing tinged with a reddish yellow, it is little more than an addition of the colours.

Grounds may be produced by mixing the Prussian blue, or distilled with king's yellow, and the effect will be rendered extremely by laying them on a ground of leaf-gold. They may any of them successfully with good seed-lac varnish, for the reasons before

Orange Coloured Grounds may be formed by mixing vermilion, or red with king's yellow or orange lake; or red orpiment will make a brighter or ground than can be produced by any mixture.

Purple Grounds may be produced by the mixture of lake or vermilion Prussian blue. They may be treated as the rest with respect to the varni

Black Grounds may be formed by either ivory-black or lamp-black; but former is preferable. These may be always laid on with the shell-lac var and have their upper or polishing coats of common seed-lac varnish.

Common Black Japan Grounds on Metal, by means of heat, are thus perform The piece of work to be japanned must be painted over with drying oil, when it is moderately dry, must be put into a stove of such heat as will ch the oil black without burning it. The stove should not be too hot when work is put into it, nor the heat increased too fast, either of which errors w make it blister; but the slower the heat is augmented, and the longer continued, provided it be restrained within a due degree, the harder will be coat of japan. This kind of japan requires no polish, having received, w properly managed, a sufficient one from the heat.

The Tortoise-shell Ground, produced by heat, is not less valuable for its g hardness, and bearing to be made hotter than boiling water without dam than for its beautiful appearance. It is to be made by means of a var prepared in the following manner:—Take one gallon of good linseed oil, half a pound of amber; boil them together till the oil becomes very brown thick; strain it then through a coarse cloth, and set it again to boil, in w state it must be continued till it acquire a consistence resembling that of pi it will then be fit for use. Having thus prepared the varnish, clean well substance which is to be japanned; then lay vermilion, tempered shell-lac varnish, or with drying oil very thinly diluted with oil of turpent on the places intended to imitate the more transparent parts of the tort shell. When the vermilion is dry, brush the whole over with black var tempered to a due consistence with the oil of turpentine. When set and f put the work into a stove where it may undergo a very strong heat, which s be continued a considerable time: if even three weeks or a month it will better. This ground may be decorated with painting and gilding in the s manner as any other varnished surface, which had best be done after the gro has been hardened; but it is well to give a second annealing with a more ge heat after it is finished. A very good black japan may be made by mixi little japan gold size with ivory or lamp-black; this will bear a good g without requiring to be varnished afterwards.

Of Painting Japan Work. Japan work should be painted with colour varnish; and in that case, all pigments or solid colours whatever may be u and the peculiar disadvantages which attend several kinds, with respect to or water, cease with regard to this sort of vehicle, for they are secured b when properly managed, from the least hazard of changing or flying. preparation of colours for this use consists, therefore, in bringing them to a state of fineness, by grinding on a stone in oil of turpentine. The varnish for binding and preserving the colours, is shell-lac; this, w judiciously managed, gives such a firmness and hardness to the work, that, be afterwards further secured with a moderately thick coat of seed-lac var it will be almost as hard and durable as glass. The method of paintin varnish is, however, more tedious than in oil or water. It is therefore now usual in the japan work, for the sake of dispatch, and in some cases for freer use of the pencil, to lay the colours on with oil well diluted with spiri turpentine. This oil or japan gold size, as it is called, may be made in following manner:—Take one pound of linseed oil, and four ounces of animi; set the oil to boil in a proper vessel, and then add the gum a gradually in powder, stirring it well, until the whole be commixed with the Let the mixture continue to boil till it appears of a thick consistence, and strain the whole through a coarse cloth, and keep it for use. The colours also sometimes laid on in gum water, but the work done in this manner is near so durable as that done in varnish or oil. However, those who pra

japanning for their amusement only, and consequently may not find it worth their while to encumber themselves with the preparations necessary for the other methods, may paint with water colours. If the colours are tempered with strong isinglass size and honey, instead of gum water, the work will not be much inferior to that done by the other method. Water colours are sometimes laid on grounds of gold, in the manner of other paintings, and look best without any varnish over them; and they are sometimes so managed as to have the effect of embossed work. The colours in this way of painting are prepared by means of isinglass size corrected with honey or sugar candy. The body with which the embossed work is raised, is best formed of strong gum water, thickened to a proper consistence with bole armenian and whiting in equal parts; which, being laid on in the proper figures, and repaired when dry, may be then painted with the intended colours tempered in the isinglass size, or in the general manner with shell-lac varnish.

Of Varnishing Japan Work.—The last and finishing process in japanning consists in the laying on and polishing the outer coats of varnish, which are equally necessary whether the plain japan ground be painted on or not. This is generally best done with common seed-lac varnish, except on those occasions where other methods have been shown to be more expedient; and the same reasons which decide as to the propriety of using the different varnishes as regards the colours of the ground, hold equally with those of the painting; for where brightness is a material point, and a tinge of yellow would injure it, seed-lac must give way to the whiter resins; but where hardness and tenacity are essential, it must be adhered to; and where both are necessary, a mixed varnish must be adopted. This mixed varnish should be made of the picked seed-lac, as directed in the case of the white japan grounds. The common seed-lac varnish may be made thus:—Take three ounces of seed-lac, and wash it well in several waters; then dry it and powder it coarsely, put it, with a pint of rectified spirit of wine, into a bottle, so that it be not more than two-thirds full, shake the mixture well together, and place the bottle in a gentle heat till the seed appear to be dissolved, the shaking being in the meantime repeated as often as may be convenient; and then pour off all the clear, and strain the remainder through a coarse cloth. The varnish thus prepared must be kept for use in a bottle well stopped. The whiter seed-lac varnishes are used in the same manner as the common, except with regard to the substance used in polishing; which, where a pure white, or great clearness of other colours is in question, should be itself white; while the browner sorts of polishing dust, as being cheaper, and doing their business with greater dispatch, may be used in other cases. The pieces of work to be varnished should be placed near the fire, or in a warm room, and made perfectly dry, and then the varnish may be laid on with a flat camel-hair brush made for the purpose: this must be done very rapidly, but with great care; the same place should not be passed twice over, in laying on one coat, if it can possibly be avoided: the best way of proceeding is to begin in the middle, and pass the brush to one end, then, with another stroke from the middle, pass it to the other end, taking care that, before each stroke, the brush be well supplied with varnish. When one coat is dry another must be laid over it in like manner, and this must be continued at least five or six times. If, on trial, there be not a sufficient thickness of varnish to bear the polish, without laying bare the painting or ground colour underneath, more must be laid on. When a sufficient number of coats is thus laid on, the work is fit to be polished; which must be done, in common cases, by rubbing it with a piece of cloth, or felt, dipped in tripoli, or pumicestone finely powdered. But towards the end of the rubbing a little oil of any kind should be used with the powder; and when the work appears sufficiently bright and glossy, it should be well rubbed with the oil alone, to clean it from the powder, and give it a still greater lustre. In the case of white grounds, instead of the tripoli, fine putty or whiting should be used, but they should be washed over to prevent the danger of damaging the work from any sand, or other gritty matter, that may happen to be mixed with them. It greatly improves all kinds of japan work to harden the varnish by means of heat, which, in every degree

that it can be applied, short of what would burn or calcine the matter, tends to give it a more firm and strong texture. Where metals form the body, therefore, a very hot stove may be used, and the work may be continued in it a considerable time, especially if the heat be gradually increased; but where wood, or *papier maché* is in question, heat must be sparingly used.

JIB. The projecting frame of a crane, to which the weight or goods are suspended; the term is a corruption of *gibbet*, evidenced by the similarity of structure. Jib is also the name of the foremost sail of a ship.

JIB-BOOM is a continuation of the bowspit forward, being run out from its extremity in a similar manner to a top-mast on a lower mast. There is also the *flying* jib-boom, which is a boom extending beyond the preceding, by passing through two boom-irons fixed to the same.

JIGGER. A machine consisting of a piece of rope about five feet long, with a block at one end, and a sheave at the other, used to hold on the cable when it is heaved into the ship by the revolution of the windlass. This is done by passing the tail round the cable near the windlass, and the hind part of the rope, coming over the sheave, is stretched aft by means of another rope passing round the jigger block.

JUNK. Remnants or pieces of old cable, which are usually cut into small pieces for making mats, gaskets, &c.

JURY-MAST. A temporary mast erected in a ship in the place of the proper one.

K.

KALEIDOSCOPE. An instrument for creating and exhibiting an infinite variety of beautiful forms, pleasing the eye by an ever-varying succession of splendid tints and symmetrical figures, and enabling the observer to render permanent such as may appear appropriate for any branch of the ornamental arts. This instrument, the invention of Dr. Brewster, in its most common form consists of a tin tube, containing two reflecting surfaces, inclined to each other at any angle which is an aliquot part of 360°. The reflecting surfaces may be two plates of glass, plain or quicksilvered, or two metallic surfaces, from which the light suffers total reflection. The plates should vary in length, according to the focal distance of the eye: five, six, seven, eight, nine, and ten inches, will, in general, be most convenient; or they may be made only one, two, three, or four inches long, provided distinct vision is obtained at one end, by placing at the other an eye-glass whose focal length is equal to the length of the reflecting planes. The inclination of the reflector that is in general most pleasing is 18°, 20°, 22½° or the 20th, 18th, and 16th part of a circle; but the planes may be set at any required angle, either by a metallic, a paper, or cloth joint, or any other simple contrivance. When the two planes are put together, with their straightest and smoothest edge in contact, they will have the form of a book opened at one side. When the instrument is thus constructed, it may be covered up either with paper or leather, or placed in a cylindrical or any other tube, so that the triangular aperture may be left completely open, and also a small aperture at the opposite extremity of the tube. If the eye be placed at the aperture, it will perceive a brilliant circle of light, divided into as many sectors as the number of times that the angle of the reflectors is contained in 360°. If this angle be 18°, the number of sectors will be 20; and whatever be the form of the aperture, the luminous space seen through the instrument will be a figure produced by the arrangement of twenty of these apertures round the joint as a centre, in consequence of the successive reflections between the polished surfaces. Hence it follows that if any object, however ugly or irregular in itself, be placed before the aperture, the part of it that can be seen through the aperture will be seen also in every sector, and every image of the object will coalesce into a form mathematically symmetrical, and highly pleasing to the eye. If the object be put in motion, the combination

of images will likewise be put in motion, and new forms, perfectly different, but equally symmetrical, will successively present themselves, sometimes vanishing in the centre, sometimes emerging from it, and sometimes playing around in double and opposite oscillations. When the object is tinged with different colours, the most beautiful tints are developed in succession, and the whole figure delights the eye by the perfection of its forms, and the brilliancy of its colouring. The eye-glass placed immediately against the end of the mirrors, as well as another glass similarly situated at the other end, is of common transparent glass. The tube is continued a little beyond this second glass, and at its termination is closed by a ground glass, which can be put on and off. In the vacant space thus formed, beads, pieces of coloured glass, and other small bright objects are put. The changes produced in their position by turning the tube give rise to the different figures.

KAOLIN. The name given to a kind of earth, which forms one of the ingredients in the manufacture of oriental porcelain. The other ingredient, which is called petuntse, is easily vitrifiable, while kaolin is scarcely so; hence, it is said, the action of the fire upon the mixture causes that semi-vitrification called porcelain. M. Bomare, who analysed some Chinese kaolin, states its composition to be a compound earth, consisting of clay, to which it owes its tenacity; of calcareous earth, whence its mealy appearance; and of crystals of mica and quartz. Similar earths to the kaolin are often found in the neighbourhood of granites.

KEDGE. A small anchor used to keep a ship steady and clear from her bower anchor while she rides in a harbour or river. They are generally furnished with an iron stock, which is easily displaced for the convenience of stowing.

KEEL. The principal piece of timber in a ship, which is usually first laid on the blocks in building; it supports and unites the whole fabric, since the stem and stern posts which are elevated on its ends, are, in some measure, a continuation of the keel, and serve to connect and enclose the extremities of the sides by transoms, as the keel forms and unites the bottom by timbers.

False-keel is a strong thick piece of timber bolted to the bottom of the keel, which is very useful in preserving its lower side; in large ships of war the false keel is composed of two pieces called the upper and lower false keels.

Keel is also a name given to a low, flat bottomed vessel, used in the river Tyne to bring the coals down from Newcastle for loading the colliers; hence a collier is said to carry so many keels.

KEELSON. A piece of timber forming the interior of the keel, being laid upon the middle of the floor-timbers immediately over the keel, and serving to bind and unite the former to the latter by means of long bolts driven from without, and clinched on the upper side of the keelson.

KELP. A very impure carbonate of soda, obtained by the incineration of sea-weed, and chiefly employed in the manufacture of glass. The cultivation of the marine plants for this purpose is now much encouraged, from the increased value it gives to those estates which have an extent of coast adapted to the growth of the peculiar kinds of weed best suited to the manufacture of kelp. There is a very great difference in the product of soda from different plants, some yielding as much as 5 per cent. of the alkali, while others, not even 1 per cent. Those parts of the coast which are exposed to the fury of tempests, or to a heavy rolling surf, prevent the plant from taking root. They thrive best in sheltered bays, where the retreat of the tide leaves uncovered an extensive surface of rocky ground, to which the plants adhere by their roots. The plant commonly called tangle is the only one to be obtained in exposed situations; these adhere with great force to the rocks, and are obtained at the low ebb of spring tides; they are however of a substantial nature, and are considered to repay well for the labour of collecting, which is usually effected by cutting them off with a sickle or reaping hook. The spring is the best time for making kelp. The marine plants, or sea weeds, are collected without distinction of kind, under the general term of wrack, or verack (which are probably corruptions of the French word *vraic*), and are first dried in the air and

sun precisely in the same manner as in the making of hay, being spread and made up into cocks and stacks, so as to keep it as much as possible from the rain; care is likewise taken to prevent its getting muddy; and such as may collect mud in dragging it up the beach, is washed in the waves by means of pitch-forks or rakes. Experience has determined that the kilns for burning vraic should not exceed about 3 feet in width inside, nor more than 2 feet 6 inches high, but they may be of any convenient length; usually they are about 18 feet. In some places holes are dug in the ground to form the kilns, which are lined with stone; but in these all the vraic is rarely completely burned, and the unburned portion yields no alkali. It is now generally deemed preferable to erect the kiln on a firm level piece of ground, of such rough stones as can be easily got together, and without mortar or cement, but the windward side of the kiln is generally covered up with turfs on the outside, and if the wind be violent, on all sides. The process of burning is commenced by igniting some furze or heath in the kiln, on which the vraic is then thrown lightly in small quantities at a time, until the whole body of the kiln is fully ignited. The additions are then continued to be made with care, by only throwing on small quantities at a time, where a red hole appears in the mass; and thus the feeding is continued until the collection of vraic is expended; then as soon as red holes appear, the less ignited portion is stirred into them. The want of due attention to the thorough and uniform burning of the vraic, causes a great deterioration in the value of the product. Towards the close of the burning, three or four men are usually employed in actively raking the ashes with the kelp-irons until the whole contents of the kiln become a semi-fluid mass. Sometimes a portion of the kelp will be found congealed to the sides of the kiln; this is then removed and worked up with the rest, that it may incorporate whilst hot. If after the raking is begun, the materials still continue hard and dry, they are allowed to burn a little longer. Sometimes common salt and saltpetre are added to the ashes to increase the ignition and bring the ashes to the desired semi-fluid consistence; but this measure is seldom found necessary, except when the vraic has been wetted by rain prior to burning. When a new burning is commenced, the remaining unfused ashes from the previous operation are introduced into the kiln by degrees along with the fresh vraic, but not until the fire has become fierce, and the largest and hardest pieces should be put in a row along the centre of the kiln. The kelp, after being made, should be carefully preserved from moisture. In Scotland the kelp makers usually break the lumps into pieces of about 2 cwt. each, which are piled into conical heaps, covered with dry vraic, and over all a layer of turf; this preserves it well until the time of shipment. Kelp is esteemed of good quality when, on breaking a piece, it is hard, solid, and has some reddish and light blue shades running through it. When it has none of its peculiar salt taste, it is unfit for making ley, though it may be of use to glass makers.

KERMES, is an insect found in many parts of Asia and the south of Europe On account of their figure they were a long time taken for the seeds of the tree on which they feed, whence they were called grains of kermes; they also bore the name of vermilion. It has been much used in dyeing worsted and woollen cloth of a scarlet colour, though the preference is given to the scarlet from cochineal, especially since the discovery of the mode of heightening its tint by the solution of tin.

KERMES-MINERAL is usually prepared by 1 pound of common antimony with 22½ lbs. of the sub-carbonate of potash, and 20 gallons of water in an iron pot, filtering the liquor whilst hot into earthen pans, and letting it cool slowly for 24 hours, the kermes-mineral is deposited in the form of a powder of a deep purple brown colour. The supernatant liquid, which yields an orange coloured sediment, called the golden sulphur of antimony, is much used by the calico printers in the following manner:—They evaporate and crystallize the supernatant liquor; the crystals are then dissolved in fresh water, and with this solution, thickened with starch or gum, they print their cloths; the cloths after being dried, are passed through a weak acid liquor, which separates the golden sulphur and fixes it on the cloth. M. Fabroni states that a much finer

kermes-mineral may be obtained by employing tartar in lieu of the alkali in the usual process. Three or four parts of the tartar are to be mixed with one part of powdered sulphuret of antimony, and exposed to a red heat in a crucible, until the entire decomposition of the tartar is indicated by the cessation of fumes; the mass should then be dissolved in warm water, be filtered, and left to cool, when an abundance of very fine deep coloured kermes will be deposited in the bottom of the vessel. This abundance of the kermes is, however, not attended with any diminution of the quantity or brilliancy of the golden sulphuret subsequently obtained by the addition of acid to the mother liquor.

KETCH. A vessel equipped with two masts, viz. the main-mast and the mizen-mast, and usually from 100 to 200 tons burthen. A bomb-ketch is a vessel rigged ketch fashion, and equipped for firing mortars.

KEY. An instrument for opening locks, &c. This term is applied to a great variety of things which it is needless even to enumerate.

KEY or QUAY. A long wharf by the side of a harbour, river, or canal, furnished with posts and rings, whereby ships and boats may be secured; also with cranes, capstans, and other convenient mechanism for loading and unloading.

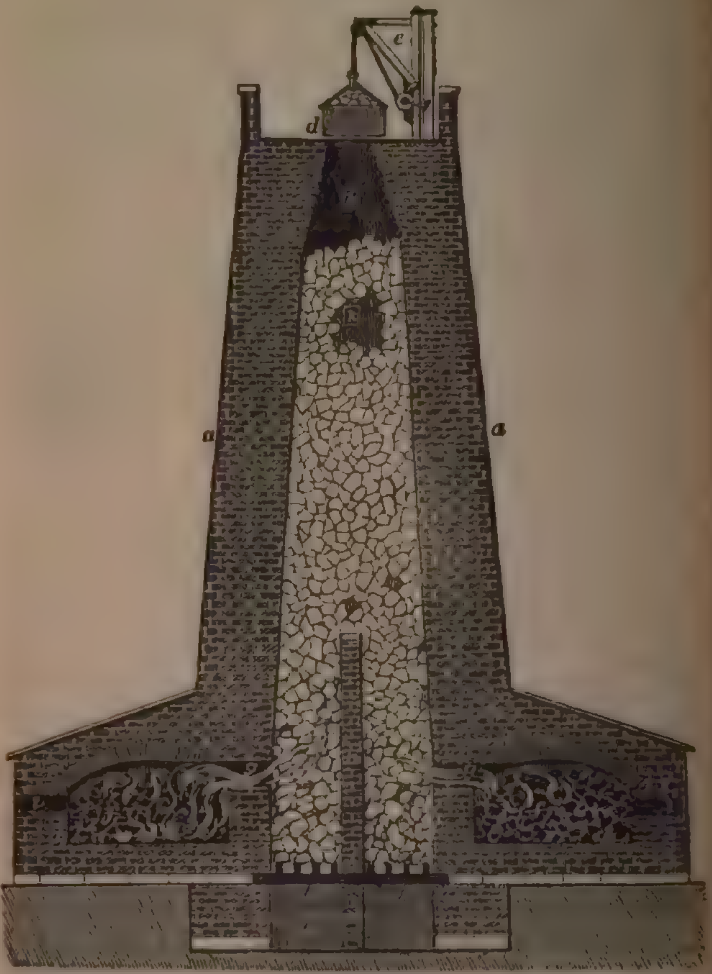
KILDERKIN. A cask that holds 2 firkins or 18 gallons, or 72 quarts. Two kilderkins are a barrel, three a hogshead, and six a butt.

KETTLE. A general name given to variously formed vessels employed in culinary and other operations. Mr. D. Gordon introduced an improvement upon them, which is explained by the subjoined cut. It consists simply in inclosing them in an outer casing which surrounds their sides, but leaves them open at the bottom for the flame of a lamp to act upon it. When heat is applied to vessels so constructed, the plate of air between the cases acquires such a temperature in the upper part as to be capable of melting a rod of glass if passed up the cavity. In kettles of the usual construction, a much greater part of the heated air escapes, without producing any useful effects, than in Mr. Gordon's, which is proved by water being sooner boiled in the latter; an economy of time as well as of fuel is thus obtained. Mr. Gordon had various other culinary vessels constructed on a similar plan.

KILN. A structure or machine designed for drying substances by the application of heat. Their forms are as various as the substances or manufacture for which they are designed; for, although it may be said that a certain kiln will answer several purposes, yet for one single purpose we often find a variety of kilns employed. The requisite qualities in a good kiln are cheapness and durability of construction; effectiveness in producing the required result with the utmost economy of fuel; a perfect command of the temperature, and facility of working. Ovens must be regarded as of the same class of apparatus as kilns; indeed, the terms kiln and oven are often indiscriminately applied to the same structure, as may be noticed under several articles in this work. Under the head of LIME the usual form of lime-kilns is described; and under COAL and IRON, several forms of coke ovens. In this place we shall notice an admirable combination of both, which was the subject of a patent granted to Mr. Charles Heathorn about seven years ago, since which time it has been in successful operation at Maidstone and other places.

Heathorn's Patent Combination of a Lime-kiln with a Coke-oven.—The object of this invention, as expressed in the specification of the patent, is the preparation of quick-lime and coke in the same kiln at one operation. The economy of this process must be evident from the circumstance, that the inflammable part of the coal which is separated to form it into coke, is the only fuel employed to burn the lime; and as the coke is in many places as valuable as the coal from which it is prepared, the cost, if any, of making lime, must be reduced to the most trifling amount. The engraving on the following page represents a vertical section of the lime shaft and coke ovens: *a a* are the side walls, 4 feet thick, of a rectangular tower, the internal space being filled with lime-stone from the top to the iron bars *b b* at bottom, whereon the whole

column rests. The lime-stone is raised in a box *d*, or other proper receptacle, to the top of the building, by means of a jib and crane *e*, or other tackle, which is fixed at the back of the tower, together with a platform projecting beyond the walls for affording security and convenience for "landing" the lime-stone: when raised as represented, the jib is swung round, and the lime-box tilted, by which the whole contents are thrown down the shaft. The coke ovens, of



which there may be two, or a greater or lesser number, according to the magnitude of the works, are constructed and arranged in connexion with the lime shaft in the same manner as the two represented in the diagram at *f f*. These ovens are supplied with coal through iron doors in the front wall (not seen in the section); the doors have a long and narrow horizontal opening in the upper part of them to admit sufficient atmospheric air to cause the combustion

of the bituminous or inflammable part of the coal; the flames proceeding from thence pass into the lime shaft through a series of lateral flues (two of which are brought into view at *g g*), and the draft is prevented from deranging the process in the opposite oven by the interposition of the partition wall *h*, which directs the course of the heat and flames throughout the whole mass of the lime, the lowermost and principal portion of which attains a white heat, the upper a red heat, and the intervening portions the intermediate gradations of temperature. When the kiln is completely charged with lime, the openings in front and beneath the iron bars at *i i* are closed and barricaded by bricks and an iron-cased door, which is internally filled with sand to effectually exclude the air, and prevent the loss of heat by radiation; therefore, when the kiln is at work, no atmospheric air is admitted but through the narrow apertures before mentioned in the coke oven doors. When the calcination of the lime is completed, the barricades at *i i* are removed, the iron bars at *b b* are drawn out, by which the lime falls down and is taken out by barrows. It sometimes happens, however, that the lime does not readily fall, having caked or arched itself over the area that encloses it, in which case a hooked iron rod is employed to bring it down. To facilitate this operation in every part of the shaft where it may be necessary, a series of five or six apertures, closed by iron doors, is made at convenient distances from the top to near the bottom of the shaft; two of these are brought into view at *k k*. Two similar apertures are shown in section in the coke ovens at *b b*, which are for the convenience of stoking and clearing out the lateral flues *g g* from any matter that might obstruct the free passage of the heated air. When the coals have been reduced to coke, the oven doors in front (not shown) are opened, and the coke taken out by a peel iron, the long handle of which is supported upon a swinging jib that acts as a movable fulcrum to the lever or handle of the peel, and facilitates the labour of taking out the contents of the oven. The operation of this kiln is continuous, the lime being taken from the bottom whenever it is sufficiently burned, and fresh additions of raw lime-stone being constantly made at the top.

Kiln for Drying Corn.—If air and moisture be carefully excluded from grain, it may be kept uninjured for an indefinite length of time. This is proved by an extraordinary experiment made with some Indian corn found in the graves of the ancient Peruvians, buried more than 300 years ago. Some of this corn being sown, it vegetated and came to maturity: we believe a similar fact is recorded respecting some grain found in the ruins of Herculaneum. But to preserve corn, even for a short period, it should be perfectly dry when housed, and carefully protected from dampness; but it not unfrequently happens, during a wet harvest season, that the corn is necessarily carried from the field in a damp state; and as few farmers have the means of properly and speedily drying it, large quantities are irrecoverably spoiled after all the labour and cost of production. The method of drying on the perforated floor of a kiln, (which is usually resorted to *where it can be obtained*,) is a very tedious, defective, and expensive mode, and is attended with great labour, owing to the grain requiring to be continually turned over and spread by a workman, whose utmost care is insufficient to cause every part to receive an equal degree of heat; it therefore becomes a matter of considerable importance to devise a simple, efficacious, and economical method of drying grain under these circumstances, and we think Mr. Jones's apparatus for this purpose (shown in the engraving on the next page) is well adapted to the end proposed. *Fig.* 1 is a vertical section of the apparatus, which is formed of two iron cylinders *a b*, placed one within the other, each being closed at the upper and lower end by two concentric cones *c d*. The annular space between the cylinders, as also between the cones, is an inch and a quarter in width, for the reception of the grain, to be dried by its passing through the machine; both the internal and external bodies are perforated throughout with about 2300 holes to the square foot. The kiln is supported on five cast-iron columns or legs, three of which are shown in the section as at E, these are attached to a strong iron ring which surrounds the base of the cylinder. From the heads of these columns descend, along the sides of the cone, five long bolts, as at G, which are passed through the same number of legs in

the cast-iron ring surrounding the neck of the lower cone: from this ring proceed five stays, as at I, which are fastened to the middle of the columns by a nut on each side. The body is sustained, both externally and internally, by iron hoops, as at K, and the distance between the cylinders is preserved by a number of short stays. In the front of the kiln a passage is cut out, as at O, in which is fixed the fire-place, through which are passages for the heated air to pass into the cylinder. These passages, as well as the flues, which proceed

Fig. 3.

Fig. 2.

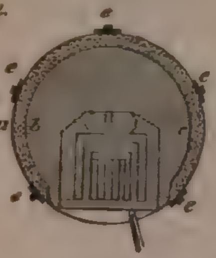
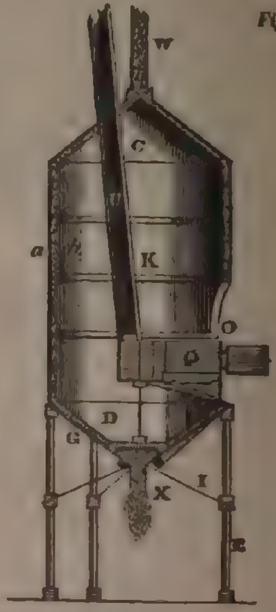


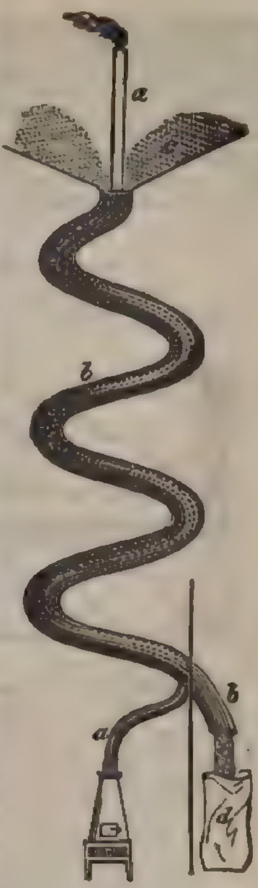
Fig. 1.



circuitously from the fire to the chimney, are best shown in the horizontal section, *Fig.* 2; and in the vertical section of the detached fire-place, *Fig* 3, Q is the fire-hole, S the ash-hole, T the fire-bars, and U the chimney, which passes up nearly in the middle of the kiln. The wheat is admitted into the kiln from above through a hopper and through the tube W, and falling upon the apex of the cone is distributed equally on all sides between the cylinders, the little asperities in which, not only slightly retard the descent of the grain, but likewise impart to the particles, a constant, slow, rolling motion, whereby every individual grain is exposed to the same degree of temperature; the grain from thence converges into the lower cone, and ultimately escapes through the spout at bottom into sacks or on to the ground as may be required. The passage of the grain through the machine may be either accelerated or retarded, according to its peculiar condition, by enlarging or contracting the aperture through which it is discharged. The moisture is carried off by evaporation through the perforations of the plates with great rapidity. The kilns may of course be made of any dimensions; one of six feet internal diameter, and twelve feet in length, between the apexes of the upper and lower cones, has been said to be capable of perfectly drying more than 100 quarters of wheat in 24 hours.

The following contrivance for drying grain has been noticed in several French papers, and announced as having been successfully adopted in one of

the departments; the plan, however, originated with a correspondent in the *Register of Arts*. The apparatus consists of a long spiral tube *a a* like a distiller's worm, reaching from the basement to the upper floor and through the roof of the granary, which forms a passage for the heated air from a close stove below. Externally round this tube is placed another tube *b b*, winding like the interior one in a spiral direction, and at about an inch and a half from it; this external tube receives the corn from above through a hopper *c*, and it is punched throughout with numerous small holes, through which the vapour escapes, as it is formed by the damp corn coming in contact with the inclosed heated chimney; the corn in consequence becomes thoroughly dried before being discharged at the bottom, and that without the intervention of any manual labour.



Hebert's Patent Kiln.—Under the article Corn is described an apparatus for washing and separating the impurities with which grain is always to a greater or less extent contaminated, and, as a necessary concomitant to that machine, a kiln was devised for drying the washed grain; but as this kiln is equally applicable to the drying of malt, seeds, and all other matters of a similar kind and form, and by a mode that is as novel as it is efficacious, we give a description of it in this place. In the engraving on the next page, *Fig.* 1 exhibits a longitudinal section of the apparatus, and *Fig.* 2 a transverse section of a long air-trough, shown at *e* in *Fig.* 1. At *a* is shown one of a series of five or six common iron gas tubes, placed side by side, and curved in the form represented to constitute a fire-place, the space between the tubes serving for the admission of air for combustion, which enters through the ash-pit door *b* at the side, provided with an air regulator: the fire-place is inclosed in front at *c* by a common door and frame. The heated air, and other products of combustion from the fuel, pass along the flue *d* to the funnel or chimney; the bottom and two sides of the flue *d* are of brick, but the top is of iron, being formed of the bottom of a long shallow iron box or air-trough *e*; this box has no cover but one of extremely open woved canvas, which forms a part of an endless cloth or band *f f f*, that is continually made to travel lengthwise over the whole area of the said trough; the edges of the cloth gliding between grooves and over tie-rods, (shown in the cross section, *Fig.* 2, where the dotted line *f* indicates the endless cloth,) that prevent the cloth from sagging. This cloth is made to travel by the revolution of three rollers or drums *g*, *h*, *i*, to either of which the moving power may be applied. The cloth is kept distended by a self-acting tightening roller, which is screwed against the hopper *k*; this hopper receives the grain to be dried, and is provided with a shoe at *l*, adapted to deliver a thin and uniform stratum of grain upon the endless cloth, whilst the same is made to pass under it, and over the trough. Another endless band *m m*, of a similar fabric to the other, passes round the drums *h i* only, and is likewise provided with a self-acting tightening roller, fixable to any convenient object. The lower ends of the six tubes *a* of the fire-place before mentioned have an open

communication with a rotative blower *o*, by means of a broad channel *p p*; and the upper ends of the tubes *a* also open into another broad channel *q*, which conducts the air into the long air-trough *e*. The operation of this machine is as follows. A slow rotation, derived from any first mover, is to be given to either of the drums *g*, *h*, *i*, which will cause the endless cloth *f* to glide gradually over the top of the air-trough *e*; at the same time the blower *o* has been put into action (by connexion with the first mover) at a high velocity, so as to produce a rapid current of air, which derives an increase of temperature on passing under the heated metallic bottom of the ash-pit; hence proceeding through

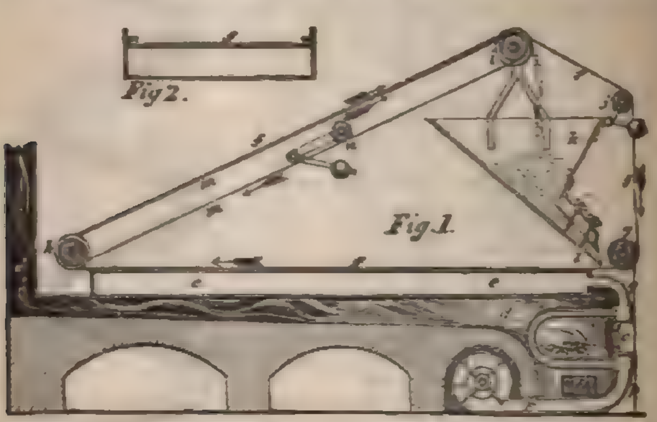


Fig 2.

Fig. 1.

the tubes *a* it acquires considerable heat, which is subsequently moderated by an extensive diffusion in the air-trough *e*, before it passes through the meshes of the endless cloth *h* above, carrying with it the moisture from the grain deposited thereon. The course taken by the endless cloth is shown by arrows in the figure; upon its arriving at the drum *h*, the other endless cloth *m m* comes in contact with the grain on the cloth *f*, and upon both the cloths passing round the said drum *h*, the corn becomes inclosed between the two cloths, and is thus carried up an inclined plane over the drum *i*, where the cloths separate, and discharge the grain back again into the hopper *k*, to undergo a repetition of the operation, should it not be perfectly dry. But when the grain is thoroughly dried, instead of allowing it to fall back into the hopper, a shoot, or the band of a creeper, (not shown in the drawing,) is brought under the roller *i*, which conducts it to the required place. A very little experience in the working of this apparatus enables a person so to regulate its operations as to complete the drying of damp grain by a single passage through it; such as varying the velocity of the air-forcer, the quantity of fuel in the stove, the supply of air through the ash-pit, the speed of the endless cloth, &c. the means of doing which are so well understood by mechanics as to render a description of them unnecessary in this place.

KITE. A fictitious bird, made of paper. This well-known juvenile plaything has been of late years applied to several objects of utility: the foremost of these, and the most paramount in importance, is the invention of Captain Dansey, for effecting a communication between a stranded ship and the shore, or, under other circumstances, where badness of weather renders the ordinary means impracticable. The following is an abbreviated description of the invention, extracted from the forty first volume of the *Transactions of the Society of Arts*, where the subject is given more in detail, with engraved illustrations.—A sail of light canvas or holland is cut to the shape, and adopted for the application of the principles of the common flying kite, and is launched [illegible] d or other point to windward of the space over which a commu-

grapnel, consisting of four spear-shaped iron spikes was fixed to the the kite, so as to moor it in its fall, and in this emergency, the attempt person to get on shore along the line, would be the means resorted to. cases where a communication has been gained, and the maintenance respondence has been the object, the person to windward has attached to the messenger, in some cases as much as three pounds, which, having ried up, has of course descended with the kite; the person to leeward furled the sail of the messenger, and loaded it with as much weight as could lift; then replacing the apparatus, and exposing the surface of to the direct action of the wind, it has rapidly risen, the messenger down the line to windward during its ascent. The kite with which nsey performed the greater part of his experiments, extended 1100 line, five-eighths of an inch in circumference, and would have extended d it been at hand. It also extended 360 yards of line, 1½ inch in ence, and weighing 60 lbs.; the holland weighed 3¼ lbs; the spars, one was armed at the head with iron spikes, for the purpose of mooring ; and the tail was five times its length, composed of 8 lbs. of rope lbs. of elm plank. A complete model of the apparatus was deposited Society, who presented Capt. Dansey with their gold Vulcan medal for tion and communication.

Viney and Pocock have also recently applied a kite for the drawing of e, in which they travelled from Bristol to London. See Vol. I. page 323.

ADING is the process of making the stiff paste of flour and water for erwards baked into bread. It is usually effected by a sort of pommel- of the hands and arms, and sometimes of the feet of the bakers. A f machines have been at different times proposed for superseding the bar- ocess we have just mentioned; they have however been but very partially the bakers in general preferring to continue their "good old-fashioned" ctice. "*Pain à la mécanique*" is, however, fashionable in Paris, and, be hoped, will ere long become so here. It is said that at Geneva all s of that city are compelled by law to send their dough to be kneaded c mill constructed for that purpose. At Genoa, also, mechanism is for kneading; the apparatus employed at this place has been pub- several of the journals, from which it appears to be so rude and ill- as not to need a description in this place.

petrisseur, or mechanical bread-maker, invented by Cavallier and Co.

roller preventing the dough from passing by it. Being thus all forced in of the compartments, the motion of the roller is reversed by turning the the contrary way, which then forces the dough back again through the space under the roller into the first compartment; in this manner the w of the dough, alternately from one compartment to the other, is continued completed.

2. Another plan was to make the trough containing the dough revolve a number of heavy balls within it. The trough in this case is made in the of a parallelopipedon, the ends being square, and each of the sides a para gram, whose length and breadth are to each other as five to one. One the trough constitutes a lid, which is removed to introduce the flour and and the trough is divided into as many cells as there are balls introduced. patentee states, that by the rotation of the trough the balls and dough elevated together, and by their falling down the dough will be subject beating, similar to the operations of the baker's hands.

3. Instead of employing a revolving cylinder, it is fixed, an agitator is to revolve, having a series of rings angularly attached to an axis, extending whole length of the trough.

4. Mr. Clayton, a baker of Nottingham, had a patent in 1830 for a mac somewhat similar to the last mentioned, inasmuch as a set of revolving a tors are employed to produce the kneading action; the agitators are lon dinal bars, fixed to arms, which radiate from the axis, and they are f through the dough in their revolution; but the cylinder in which they re and which contains the materials, is made to revolve at the same time contrary direction; the motion of the latter being imparted by a short h axis, while the axis of the former is solid and passed through the hollow The solid axis, which is turned by a winch, has on it a bevelled pinion, w by means of an intermediate bevelled wheel, actuates another bevelled p fixed on the hollow axis, and therefore causes it to revolve in the opp direction. These two simultaneous and contrary motions constitute the no claimed by the patentee, who *states*, that dough-making machines, similar t own, have all failed for want of such an arrangement. This statement, co from a baker, commands attention; but we cannot concur in its truth, sinc know that the following plan of a kneading machine works well without o site simultaneous motions, and without any agitators or beaters, which abs great deal of power without producing an adequate effect.

5. *Hebert's Patent Kneading Machine.*—In this a cylinder of from 4 to 5 in diameter, and only about 18 inches wide inside, is made to revolve upo axis, which is fixed by a pin during the revolution of the cylinder. The flo admitted by a door in the periphery, which closes air and water-tight; and water or liquor passes through a longitudinal perforation in the axis, and th through small holes amongst the flour, in quantities which are regulated e nally by a cock. By the rotation of the cylinder the dough is made to be tinually ascending on one side of it, whence it falls over upon the po below. When the mixture becomes pretty intimate and uniform, its adh property causes it to stick to the sides of the cylinder, and the dough w then be carried round without much advancing the process, were it no another simple contrivance: this is a knife-edge or scraper, 18 inches which is fixed along the top of the cylinder in the inside, so as barely to t its surface; the knife is fixed to two flat arms extending from the axis, these arms have sharp edges so as to scrape the sides of the cylinder; thu cylinder is kept constantly clean from the sticking of the dough, which, as as it ascends to the top of the cylinder (if it does not tear away of itsel shaved off by the knife, and falls down with great force upon the bottom; as this effect is constant during the motion of the cylinder, it must be ev that the process of kneading is soon completed by it. When that is done door of the cylinder is opened, and the contents discharged into a rec beneath; at which time the scraper is caused, by a winch on the axis, to one revolution of the now fixed cylinder, which clears off any adhering d and projects it through the door-way. As the dough in this machine m

said to knead itself, there being no arms, beaters, or agitators whatever, it is calculated that the power saved by it is very considerable, while, from the simplicity of its construction, the cost is moderate.

The patentee is at present engaged in combining with this kneading machine an apparatus for preparing carbonated water, highly charged with the gas, with which he proposes to mix up the flour to form dough, for the purpose of making the bread spongy or vesicular, without having recourse to the fermentative process; the result of which process, under the most favourable circumstances, he considers to be detrimental to the health of those that eat the bread, (owing to the deposition of fermentable matter in the stomach,) while it is destructive of a portion of the nutriment of the flour.

KNIVES (*including Forks*). Knives are well-known instruments, made for cutting a great variety of substances, and adapted by differences in form to various uses; but the two principal sorts may be classed under the terms of pocket-knives and table-knives, with their now necessary accompaniments, forks. The manufacture of these articles in this country is almost wholly conducted at Sheffield. Our account of the process of making them must necessarily be concise, and afford only a glimpse of the procedures, as it is manifestly impossible for us to transform the uninitiated into cutlers by any information that we can give.

In the making of pocket-knife blades, one workman and a boy are generally employed; the boy attends to the heats, (that is, to the rods of steel in the fire,) which he successively hands to the forger, and takes back the rod from which the last blade was formed. One heat is required to fashion the blade, and a second to form the tang, by which it is fastened into the handle. The skill of the forger is displayed in forming it so perfectly by his hammer, as to require but very little to be filed or ground off in the subsequent operations. The springs for the back of the knife, and the scales which form the rough metal under-handle, and to which the other pieces are rivetted, are made by a distinct class of workmen. In the forging of table-knife blades, and other blades of a similar or greater size, the forger has an assistant, who, with a large hammer, strikes alternately with him; and the hammering of all blades is continued after the steel has ceased to be soft, in order to condense the metal and render it very smooth and firm. Table-knife blades are usually made with iron backs, which are welded to the steel by a subsequent forging, to that of forming the cutting edge; the thick piece that joins the handle, called the shoulder or bolster, as well as the tang that goes through the handle, is forged out of the iron immediately after the welding of the steel blade: dies and swages being employed to perfect and accelerate the shaping of these parts. When the forging is completed, the blades undergo the processes of hardening and tempering, already explained in our account of the steel manufacture (article IRON). The blades are then ground upon a *wet* stone, about 4 feet in diameter, and 9 inches wide, which roughs out the work; they are subsequently finished or *whitened*, as it is termed, upon a finer *dry* stone; and the shoulders or bolsters are ground upon a narrow stone, about 3 feet in diameter, which completes the grinding. The next process is that of glazing the blades, which is effected upon a wooden wheel, made up of solid segments, well fitted and secured together, and with the ends of the fibres of the wood presented to the periphery of the circle; over this is extended a piece of leather, which is charged with emery or other powders, adapted to the finish or nature of the work required.

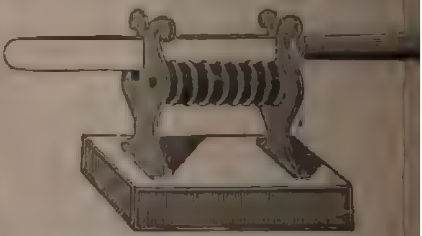
It is only about 200 years since, that table-forks were known in England, when they were introduced from Italy; and even now, in some remote parts of Scotland and Ireland, they are regarded as useless articles of luxury. The cheaper kind of forks are made by casting them from malleable pig-metal, (see IRON,) sometimes denominated "run-steel;" and some of these, which are well annealed and worked under the hammer, turn out very serviceable and good. Those made of wrought metal, were formerly either forged, and the prongs drawn out by the hammer, and welded together, or they were forged into one solid piece, and the spaces between formed by cutting away the metal. These processes, however, were tedious and expensive, and a great improvement in

their manufacture has been introduced. The tang, shoulder, and a thic piece, called the blade, are forged, and the blade is then submitted to the of a pair of dies, contained in a powerful fly or stamping-press; the dies so formed as to force or cut out the superfluous portion of the metal and the curved swelled portions at the junction of the prongs, termed the The forks after this operation are filed up, ground, glazed, and burnished, they are ready for hafting, which is a distinct business.

The instruments required for hafting knives and forks are few and The principal are, a small polishing wheel and treddle, mounted upon a a bench vice, and a kind of hand vice to fix in the bench vice, termed a dragon; it has a pair of long projecting jaws, adapted to hold a piece of or other substance, with the flat side uppermost, in order to be filed or wise worked; a few files, drills, drill-box, and breast-plate, burnisher buffs, emery, rotten stone, &c. The substances used for covering the h are almost infinite; the chief are bone, horn, ivory, tortoiseshell, and w every kind. The several pieces of the handle being filed to the shape int holes are drilled through them for the pins by which they are afterwards together. The pinning is at first loosely done; until the blades, springs, the parts are well adjusted and fit closely, they are then firmly rivetted tog The handles are afterwards scraped and then polished, by means of on the wheel.

KNIFE-SHARPENERS. This term has been given to a variety of venient modern instruments, especially adapted to the sharpening of kni table, but particularly carvers, and are intended as substitutes for the co steel. For these instruments several patents have been obtained, and a derable manufacture of them has been established.

Filton's Patent Sharpener, without its usual accompanying ornamen represented in the annexed cut; it consists of two horizontal rollers, placed parallel to each other, which revolve freely upon their axes, (represented by the two black dots;) at uniform distances, there are fixed upon each roller, narrow cylinders or rings of hard steel, the edges of which are cut into fine teeth, and thus form circular

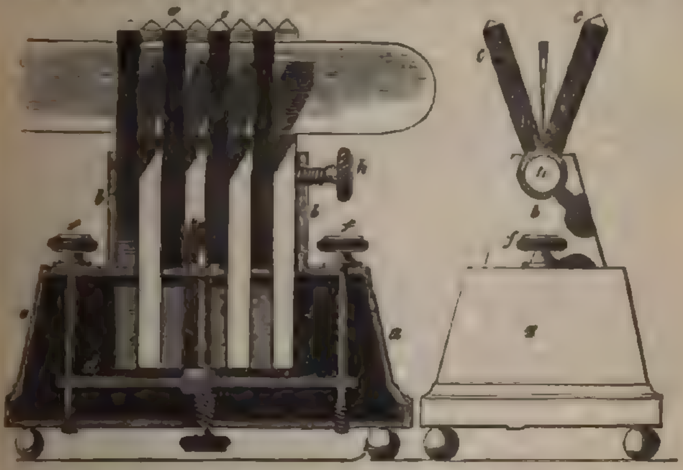


files; the edges of the files in the opposite rollers overlap each other a li that when a knife is drawn longitudinally between them, the edge of the is acted upon on both of its sides at once. The rollers turn round wit slightest impulse, consequently, they wear uniformly, and will last a consid time. A good edge is given to a knife by just drawing it from heel to two or three times between the rollers; and thus obviates the necessity o tating the skill exercised by a butcher upon his steel.

Westby's Knife-sharpener, which was patented in 1828, is a very prett ingenious instrument; an immense quantity of them have been sold, an said, have been the means of greatly enriching the proprietor of the p In the engraving on the next page, *Fig.* 1 exhibits an end elevation of strument, and *Fig.* 2 a side elevation of the bars, with a section of the b and *b*, to show the interior. The same letters in each figure have refere similar parts; *a* is a small oblong box, surmounted by a smaller box *b*; top of the latter there is a slit made throughout its length, and of su width to receive the square steel bars *c c*. The box *a* has two simila The surfaces of the bars are draw-filed, they pass through the slit in alternately through both slits in *a*, so as to cross each other, as shown in The lower ends of these bars are supported upon a plate of metal *d*, whi be elevated, so as to a bring a different portion of the bars into operati means of the screw underneath; *f f* are two screws passing through the

in *d*, to preserve its parallel motion, and likewise to support the bottom of the box; *h* is a tightening screw to steady the bars *c c*.

The mode of operating with this instrument is merely to place the edge of the knife upon the bars, so as to bisect the angle formed by them, and then



draw the knife backward and forward. As the surfaces of the bars wear away, different sides can be presented, or they can be shifted from end to end, so as to present fresh surfaces to the knife.

Church's Patent Knife-sharpener consists of two very flat truncated cones, fixed with their smaller surfaces together, and with several rectangular projections in the one, fitting into similar cavities in the other. The conical surfaces of both pieces are serrated with a series of very fine teeth extending angularly towards their centres; these are placed upon the shank of the fork, between the shoulder and the handle, with which they correspond in diameter so nearly as to constitute an ornamental finish to the small end of the handle. In the position and size of these consist the principal merit of the sharpener. When used for sharpening scythes, or other large cutting instruments, the conical pieces are made larger, and fitted on an axis between two prongs of a forked apparatus, with an appropriate handle.

Westby's second Patent.—The extraordinary success attendant upon Mr. Westby's contrivance for sharpening table-knives induced him to figure a second time as a patentee, "for certain improved apparatus to be used for the purpose of whetting or sharpening the edges of the blades of *penknives, razors, and other cutting instruments.*" The first improvement mentioned in the specification consists in the application to a hone, or oil-stone, of a guide to keep the edge of the razor, or other cutting instrument, at the same angle with respect to the surface of the hone, during the operation of whetting. This is effected in two ways; first, by placing over the hone a plate of metal extending its whole length, and adjustable, at any required distance parallel to its surface, by set screws; now, in the operation of sharpening, the back of the instrument is kept resting upon the guide-plate, while the edge is applied to the hone. The second method consists in the application of two hones placed in an erect position, with a space between them for the razor, which is to be fixed by screws into a small horizontal frame, made to slide upon a circular rod, so that the edge can be applied alternately to the hones; these can be elevated and depressed at pleasure, so that their surfaces may be uniformly worn while in use. The patentee also mentions in his specification a method of attaching to the hone a leather strap which is made double, and kept stretched by adjusting screws attached to the frame of the hone, or else to the end of a rod extending

lengthways between the two folds of leather. This last contrivance does appear to us to be scientifically adapted to the object in view, as the pres of the edge of the instrument upon a strap of leather only supported at extremities, must produce a tendency in the leather to wrap round the ac angle of the edge of the instrument, and render it obtuse.

L.

LABORATORY. A place fitted up and supplied with the necess apparatus for chemical operations. Laboratories for conducting chemic processes on a large manufacturing scale will of course vary in their arrang ments according to the main object for which they are designed. For expe mental and general purposes a laboratory is more advantageously plac above than below ground, that it may be as dry as possible; the air mu have free access to it; and it must even be so constructed that, by mean opposite openings, a current of air may be admitted to carry off nox vapours. A chimney ought to be constructed so high that a person ma easily stand under it, and extending the length of one of the side wal The chimney should be high, and sufficiently contracted to make a goo draught. When charcoal is the only fuel to be employed no soot will b deposited, and therefore it need not be so wide as to allow a chimney-sweep to pass up it. Under this chimney may be constructed some brick furnac particularly a melting furnace, a furnace for distilling with an alembic, a one or two ovens like those in kitchens. The rest of the space ought to filled up with stands of different heights, from a foot to a foot and a half, which portable furnaces of all kinds are to be placed. These furnaces are t most convenient, from the facility of disposing of them at pleasure; and th are the only furnaces which are necessary in a small laboratory. A doub pair of bellows of moderate size must also be placed as commodiously possible under or near to the chimney, and having a pipe directed towards t hearth where the forge is to be placed. The necessary furnaces are the simp furnace, for distilling with an alembic, a lamp furnace, two reverberato furnaces of different sizes for distilling with retorts; an air or melting furnac an assay furnace, and a forge furnace. Under the chimney, at a convenie height, should be a row of hooks driven into the back and side walls, up which are to be hung small shovels, iron pans, tongs, pincers, pokers, a various utensils for disposing the fuel and managing the crucibles. To t walls of the laboratory should be fixed, or suspended, rows of shelves, different breadths and heights, for containing bottles and glass vessels, wh should be as numerous as is possible, that the products of operations may be co veniently retained. The most convenient place for a stone or leaden cistern contain water, is a corner of the laboratory, and under it a sink ought to placed, with a pipe by which the water poured into it may discharge itself. the vessels are always cleaned under this cistern, cloths and bottle-brus ought to be hung upon hooks fastened in the walls near it. In the middle the laboratory a large table is to be placed, on which mixtures are to be ma preparations for operations, solutions, precipitations, small filtrations; in sho whatever does not require fire, excepting that from a lamp. In conveni parts of the laboratory are to be placed blocks of wood upon mats, one of whi is to support a middle-sized iron mortar, another a support for a middle-si marble, or hard stone mortar, and a third for an anvil. Near to the mort are to be hung sieves of different fineness and sizes; and near to the anvil, fil rasps, pincers, shears, and other convenient utensils for working metals, or giv them proper forms for the several operations; two movable trestles, to supp a large filter or other apparatus, that they may be disposed of conveniently. account of the dust from charcoal, the stock of this article had better be pla contiguous, but not inside the laboratory; also some dried furze or other qu burning fuel. In the same place may be put bulky articles, bricks, tiles, clay, li sand, and many other things useful in chemical operations. A small, solid ta for a levigating stone and muller; small mortars, of iron, glass, agate,

Wedgwood ware; earthen, stone, metal, and glass vessels of different kinds; funnels, measures, glass-tubes; spatulas of wood, metal, ivory, and glass; pasteboards, sifting paper, unsized paper, clean straws, horns, corks, bladders, linen strips, lutings, cements, paste, glue, portable bellows, brushes, boxes, &c. &c. are all occasionally wanted in a laboratory. See *Ure's Dictionary of Chemistry*.

LAC. A resinous substance, the product of an insect found on several different kinds of trees in the East Indies. These insects pierce the small branches of the trees on which they feed; and the juice that exudes from the wounds is formed by them into a kind of cells for their eggs. Lac is imported into this country adhering to the branches in small transparent grains, or in semi-transparent flat cakes. The first, encrusting the branches, is called stick-lac; the second are the grains picked off the branches, and called seed-lac; the third is that which has undergone a simple purification, as we shall presently notice. There is a fourth called lump-lac, made by melting the seed-lac, and forming it into lumps. To purify the lac for use the natives of India put it into long canvas bags, which they heat over a charcoal fire until the resin melts; a portion of the lac then exudes through the bags, which are subsequently twisted, or wrung by means of cross sticks at the ends of the bags, the surface of the latter being scraped at the same time to accelerate the process. The chief consumption of lac in this country is in the manufacture of sealing-wax and varnishes. It has been a great desideratum among artists to render shell-lac colourless, as, with the exception of its dark brown hue, it possesses all the properties essential to a good spirit varnish in a higher degree than any other known resin. A premium of a gold medal, or thirty guineas, for "a varnish made from shell or seed-lac, equally hard, and as fit for use in the arts," as that at present prepared from other substances, was offered for some years by the Society of Arts. The editor of the *Franklin Journal*, of Philadelphia, observes, in reference to the foregoing, that "these ends are perfectly attained by the process given by Dr. Hare, which leaves nothing to desire, excepting on the score of economy." Were the oxymuriate of potash to be manufactured in the large way, the two processes, that of making the salt and of bleaching the resin, might be advantageously combined. "Dissolve," (says Dr. Hare,) "in an iron kettle, one part of pearl-ash in about eight parts of water; add one part of seed or shell-lac, and heat the whole to ebullition; when the lac is dissolved, cool the solution, and impregnate it with chlorine till the lac is all precipitated. The precipitate is white, but its colour is deepened by washing and consolidation; dissolved in alcohol, lac bleached by the process above-mentioned yields a varnish which is as free from colour as any copal varnish." About the same period of time as the publication of the foregoing, the before-mentioned premium of the Society of Arts was claimed by two persons, Mr. George Field, and Mr. Henry Luning. The Society, upon a due examination of both of the processes and products, found them both to answer the intended purpose, and awarded the sum of twenty guineas to each of the candidates.

The following is Mr. Field's process: Six ounces of shell-lac, coarsely powdered, are to be dissolved by gentle heat in a pint of spirits of wine; to this is to be added a bleaching liquor, made by dissolving purified carbonate of potash, and then impregnating it with chlorine gas till the silica precipitates, and the solution becomes slightly coloured. Of this bleaching liquor add one or two ounces to the spirituous solution of lac, and stir the whole well together; effervescence takes place, and when this ceases, add more to the bleaching liquor, and thus proceed till the colour of the mixture has become pale. A second bleaching liquor is now to be added, made by diluting muriatic acid with thrice its bulk of water, and dropping into it pulverized red lead, till the last added portions do not become white. Of this acid bleaching liquor, small quantities at a time are to be added to the half bleached lac solution, allowing the effervescence, which takes place on each addition, to cease before a fresh portion is poured in. This is to be continued until the lac, now white, separates from the liquor. The supernatant fluid is now to be poured away, and the lac is to be well washed in repeated waters, and finally wrung as dry as possible in a cloth.

The lac obtained in the foregoing process is to be dissolved in a pint of alcohol, more or less, according to the required strength of the varnish; and after standing for some time in a gentle heat, the clear liquor, which is the varnish, is to be poured off from the sediment.

Mr. Luning's process is as follows:—Dissolve five ounces of shell-lac in a quart of rectified spirits of wine; boil for a few minutes, with ten ounces of well-burnt and recently heated animal charcoal, when a small quantity of the solution should be drawn off and filtered; if not colourless, a little more charcoal must be added. When all colour is removed, press the liquor through silk, as linen absorbs more varnish, and afterwards filter it through fine blotting-paper. In cases where the wax found combined with the lac is objectionable, filter cold; if the wax be not injurious, filter while hot. This kind of varnish should be used in a temperature of not less than 60° Fahr.; it dries in a few minutes, and is not afterwards liable to chill or bloom; it is therefore particularly applicable to drawings and prints which have been sized, and may be advantageously used upon oil paintings which have been painted a sufficient time, as it bears out colour with the purest effect. This quality prevents it from obscuring gilding, and renders it a valuable leather varnish to the book-binder, to whose use it has already been applied with happy effect, as it does not yield to the warmth of the hand, and resists damps, which subject bindings to mildew. Its useful applications are very numerous, indeed, to all the purposes of the best hard spirit varnishes: it is to be used under the same conditions, and with the same management. Common seed-lac varnish is usually made by digesting eight ounces of the bright, clear grained lac in a quart of spirits of wine, in a wide-mouthed bottle, putting it in a warm place for two or three days, and occasionally shaking it. When dissolved it may be strained through flannel into another bottle for use. In India, lac is fashioned into rings, beads, and other trinkets. Its colouring matter, which is soluble in water, is employed as a dye. The resinous portion is mixed with about three times its weight of finely powdered sand, to form polishing stones. The lapidaries mix powder of corundum with it in a similar manner.

LACQUERING is the application of transparent or coloured varnishes to metals, to prevent their becoming tarnished, or to give them a more agreeable colour. The basis of them is properly the lac described in the preceding article; but other varnishes made by solutions of other resins, and coloured yellow, also obtain the name of lacquer. Strictly speaking, lacquer is a solution of lac in alcohol, to which is added any colouring matter that may be required to produce the desired tint; but the recipes that have been published in various scientific journals contain apparently a great many useless articles. The following is much extolled, in *Nicholson's Operative Mechanic*, as a lacquer for philosophical instruments:—

½ oz. of gum guttæ.	½ oz. of terra merita.
2 oz. of gum sandarac.	2 oz. of oriental saffron.
2 oz. of gum elemi.	3 oz. of pounded glass;
1 oz. of dragon's blood, of the best quality.	and
1 oz. of seed lac.	20 oz. of pure alcohol.

Before, however, the reader ventures to meddle with so formidable a list of ingredients as the foregoing, we would recommend him to make trial of the following more simple compound:—Take 8 oz. of spirits of wine, and 1 oz. of annatto, well bruised; mix these in a bottle by themselves: then take 1 oz. of gamboge, and mix it in like manner with the same quantity of spirits. Take seed-lac varnish, (described under the previous article LAC,) what quantity you please, and colour it to your mind with the above mixtures. If it be too yellow, add a little from the annatto bottle; if it be too red, add a little from the gamboge bottle; if the colour be too deep, add a little spirits of wine. In this manner you may colour brass of any desired tint: the articles to be lacquered may be gently heated over a charcoal fire, and then be either dipped into the lacquer, or the lacquer may be evenly spread over them with a brush.

LACE. A delicate kind of net-work, composed of silk, flax, or cotton threads, twisted or plaited together. The meshes of this kind of net are of a

octagonal figure, in which thick threads are also woven to form the pattern according to some design; and these threads, which are called gymp, form the ornament of the lace. Buckinghamshire and Bedfordshire have been for many years the counties most celebrated for the manufacture of the pillow or bobbin lace, so called because it is woven by women or children upon a pillow or cushion, by means of bobbins, (which are made of ivory or bone, and each of which contains a small quantity of fine thread,) in such a manner as to make the lace exactly resemble the pattern, which is fixed upon a large round pillow, and pins being stuck into the holes or openings in the pattern, the threads are interwoven by means of the bobbins. At the close of the last century, the manufacturers of Nottingham directed their ingenuity to imitate this species of lace by machinery, in which they have completely succeeded. The Nottingham imitations of lace are of two kinds—point-net and warp-net. The point-net frame is a variety of the stocking frame, which was invented by Mr. John Morris, of Nottingham, in 1764; but it was not at first used to make lace, being intended to make the ancle part of stockings. The machine is an addition to a stocking frame, and operates on the thread in the same way as in stocking weaving for a great part of the process. The Nottingham lace, therefore, is only a modification of the stitch or loop of which stockings are made; all the meshes being formed by a continuance of one thread, which is by the machine formed into loops, a whole course at once, by pressing it down alternately over and under between a number of parallel needles; a second course is then made of similar loops on the same needles, and the loops of the first are drawn through those of the second in such a manner as to form meshes by retaining the first loops; the second are then retained by a third course, and thus by a fourth, and so on. The warp-net frame is also a variety of the stocking frame, but the parts are very differently arranged, the movements being produced by treadles, leaving the hands of the workman to manage the machine, which is a piece of mechanism applied in front of the row of needles of the frame. In the warp frame the piece of lace is not formed of one continued thread, as in the point-net frame, but there are as many different threads as there are needles in the frame; these threads are warped, or wound upon a roller or beam the same as a loom; and it is from this circumstance that the machine is called a warp frame. These threads pass through eyes in the ends of small points, called guides, which are opposite the needles; and these guides are fixed on two bars, each of which has half the guides fastened on it, that is, one guide is fast in one bar, and the next in the other, and so on alternately of the whole. Each of the guides presents a thread to its needle, and are all at once moved by the hand to twist the threads two or three times round the needles which are opposite them: the loop is now made in a manner similar to the other frame. The next time, the alternate guides are shifted endways, so as to apply themselves to other needles than those they were opposite before: this crosses the thread so as to make a net; but the quantity which is shifted endways is altered every time, by means of the machinery, so as to move a certain number of needles, which number is altered every time to produce the pattern. In 1809, Mr. John Heathcoat invented a machine for weaving the real twisted lace, like that which is made on the pillow. The ground-work of the invention is to extend those threads which form the warp of the lace in parallel lines, and dispose the diagonal threads upon small bobbins, which are detached, and are capable of passing round the extended warp threads, so as to twist with them; by this means, the number of bobbins is reduced to one half. In this machine there are two horizontal beams or rollers, one to contain the thread, and another to receive the lace; also a number of small bobbins to contain the thread.

Since Mr. Heathcoat's first invention, the manufacturers of Nottingham, Leicester, Tewkesbury, and many other places, have vied with him and each other in the production of lace-making machinery. In 1824 the different descriptions of machinery for making lace were enumerated under the following heads:—the old Loughborough double tier, *Heathcoat's*; the single tier on *Stevenson's* principle; improved double tier, *Brailey's*; single tier on *Lever's*

principle; the old Loughborough improved, with pumping tackle; the pusher principle; the traverse warp, *Bevan* and *Freeman's*; traverse warp rotatory, *Lindley* and *Lacey's*; the straight bolt, *Kendal* and *Mauley's*; the circular bolt, *Mauley's*; the circular comb, *Hervey's*; the circular comb improved, *Hervey's*; and the improved *Lever's*. The foregoing comprehend the different principles upon which the machinery for making bobbin-net lace have been founded.

In 1824 Mr. Longford took out a patent for actuating several of the foregoing machines by rotatory motion, which were previously worked by a beating or lever action of the hands and feet of the operator. Since the last-mentioned period there have been a great many patents taken out for improvements, the description of which alone would occupy a large volume, and require some hundreds of engravings to render them intelligible. We can therefore only refer the reader to such works as are distinguished by subjects of this nature—viz. *The London Journal of Arts*, *The Repertory of Arts*, the *Register of Patent Inventions*, and to the enrolled specifications,—for such further information that he may require.

LACTOMETER. An instrument invented by Mr. Dicas, of Liverpool, for the purpose of ascertaining the different qualities of milk from its specific gravity compared with water. On this subject Dr. Ure observes, that it is not possible to infer the quality of milk from the indications merely of a specific gravity instrument, because both cream and water affect the specific gravity of milk alike. "We must first use as a lactometer a graduated glass tube, in which we note the thickness of the stratum of cream afforded, after a proper interval, from a determinate column of new milk; we then apply to the skimmed milk a hydrometric instrument, from which we learn the relative proportions of curd and whey. Thus the combination of the two instruments furnishes a tolerably exact lactometer."

LADDER. A portable frame, containing steps for the feet. There are various kinds, most of which are too familiar to the readers of this work to need description; but there is one of a very ingenious description, described under the head of FIRE ESCAPES, invented by Mr. Gregory, which is evidently applicable to a great variety of purposes, wherein common ladders are useless, or of difficult employment. Ladders are very advantageously employed in the raising of weights, by the addition of a pulley-wheel at the top, or suspended over them; passing over this pulley is a rope, to one end of which is attached the article to be raised, (a tea-chest, for instance, out of the hold of a ship;) a man then ascends the ladder to the required height, and steps on to a foot-board, properly contrived for the purpose, which is attached to the other end of the rope just mentioned; the man's weight, then, more than counterpoising the tea-chest, *he* rapidly descends, while the chest ascends through the same space. In this manner the tea is unloaded from the East India Company's dock at Blackwall, and it is very probable there is not a more efficient mode of applying a man's labour for that purpose, and the mechanism is cheap, convenient, and easily adjustable to the space. The man has only to ascend the steps of the ladder, and he is refreshed in the descent, the frame in which he stands sliding over the inclined plane of the ladder.

Mr. W. Hilton has likewise ingeniously

converted the fixed ladder against a trap door, into a crane for lowering heavy or bulky articles, such as a pipe of wine from a warehouse into a cellar, for the communication of which invention to the Society of Arts Mr. Hilton was rewarded by an honorary medal.

A very convenient folding ladder is manufactured by Mr. Green, of Goswell-street, of which the cut in the preceding page is a representation. *Fig.* 3 shows the ladder as opened out for use; *Fig.* 2 shows the ladder in section, half open, and the manner in which the rounds are jointed to the side rails; and *Fig.* 1 exhibits the ladder folded up close, forming exteriorly a round pole, tapered at each end. Mr. Green has likewise contrived an excellent ladder for the purpose of rescuing persons who may have the misfortune to sink under ice.

LAKE. A name given to several pigments formed by precipitating colouring matter with some earth or oxide. The principal lakes are carmine, Florence lake, and madder lake; the first of these has been already described under its initial letter. See CARMINE.

Florentine lake is prepared from the sediment of the cochineal, which is deposited in the preparation of carmine, and the red liquor also remaining from the same; these are boiled with the requisite quantity of water, and afterwards precipitated with the solution of tin: this precipitate must be frequently edulcorated with water. Exclusive of this, two ounces of fresh cochineal, and one of crystals of tartar, are to be boiled with a sufficient quantity of water, poured off clear, and precipitated with the solution of tin, and the precipitate washed. At the same time two pounds of alum are also to be dissolved in water, precipitated with a lixivium of potash, and the white earth repeatedly washed with boiling water. Finally, both precipitates are to be mixed together in their liquid state, put upon a filter and dried. A cheaper kind of crimson lake is prepared,—Brazil-wood may be employed instead of cochineal, and treated in the foregoing manner.

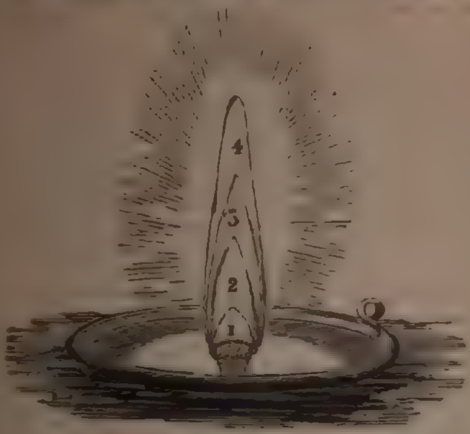
Several modes of preparing fine red lakes from the madder of different countries were communicated to the Society of Arts by Sir H. C Englefield, to whom the Society awarded a gold medal for the same. The following is his process of preparing it from the Dutch crop-madder:—Two ounces troy of the finest quality is to be inclosed in a bag of fine and strong calico, large enough to hold three or four times as much; put it into a large marble or porcelain mortar, and pour on it a pint of clear soft water, cold; press the bag in every direction, and pound and rub it about with a pestle, as much as can be done without tearing it, and when the water is loaded with colour, pour it off. Repeat this process by adding fresh water till all the colour is extracted. Heat all the liquor in an earthen or tinned copper vessel, or what is better, a silver vessel, until it just boils; then pour it into a large earthen vessel, and add to it one ounce troy of alum, dissolved in a pint of boiling soft water, which must be thoroughly mixed. Pour in about an ounce and a half of a saturated solution of sub-carbonate of potash; a precipitation will ensue; let it stand till cold, when the supernatant clear, yellow liquor may be poured off from the red precipitate. A quart of boiling water should again be poured on it and well stirred. When cold, the colour may be separated from it by filtration through paper in the usual way; and boiling water should be poured on it in the filter till it passes through of a light straw colour, and free from an alkaline taste. The colour may now be gently dried, and when quite dry it will be found to weigh half an ounce: just a fourth part of the weight of the madder employed. If less alum be employed, the colour will be somewhat deeper: with less than three-fourths of an ounce, the whole of the colouring matter will not unite with the alumina. One ounce of alum to two ounces of madder is the best proportion. Spanish madder affords a colour of rather a deeper tint than the Dutch madder, but does not appear of so pure a red as the Zealand crop-madder. The lake produced from the foregoing process from Smyrna madder is remarkable for the richness and depth of its tint: the colour may be obtained from the fresh roots of madder, and will prove of equal if not superior quality to the dry. Upon the whole, the author of these processes considers the essential advantage of them to

consist in the trituration or pressing of the root in *cold* water. Almost all vegetable colouring matters may be precipitated into lakes, more or less beautiful, by means of alum or oxide of tin.

LAMP. A vessel in which fluid combustibles are burned for the purpose of affording artificial light. This is effected by means of a wick or burner (commonly composed of a few threads of linen or cotton), which is immersed in the fluid, and its upper extremity lighted; the fluid then rising gradually by capillary attraction to the lighted end becomes decomposed, and its constituent parts form various gaseous compounds, most of which are inflammable, and these take fire and burn with a degree of brilliancy varying with the nature of the fluid from which they are obtained. The wick being now surrounded by the flame of the burning gases is maintained at a heat sufficient to decompose fresh portions of the combustible matter as they continue to rise to it. The office of the wick, therefore, is merely to decompose the oil or other fluid, and not to afford light by the burning of its own substance; for although the wick or burner is generally composed of some combustible material, yet provided that it be kept plentifully supplied with oil it is consumed so slowly as to afford no perceptible increase of light; and frequently wicks composed of incombustible substances are employed, as asbestos, metallic wire, glass, &c.; and some years back Messrs. S. and D. Gordon obtained a patent for lamps with incombustible wicks, formed of the above-named substances, by drawing the material into fine threads, which are afterwards formed into small bundles and bound round spirally with wire, or rolled up in a piece of fine wire gauze, forming a cylindrical bandage or covering to each bundle. The wicks thus formed contain a vast number of minute interstices, arranged longitudinally in parallel lines, which being placed in an inflammable volatile liquid (as naphtha or alcohol), the liquid is conveyed by capillary attraction to the upper part of the wick for ignition. The composition to be burned in these lamps constitutes another branch of the improvements mentioned in the patent, and consists of a mixture of one part of essential oil with five or six of alcohol or naphtha (which latter is much more economical.) By this admixture a much more brilliant light is obtained than when alcohol alone is used, whilst the smoke and deposit of carbonaceous matter upon the wick which attends the combustion of essential oils by themselves is avoided. These lamps have been made up into a great variety of elegant designs, both modern and antique; they have also been fitted into frames and stands to be placed under tea-urns, coffee-biggins and tea-kettles, and are extremely convenient in numerous situations, while the expense is inconsiderable. They have a circular ring at top for receiving the kettle or other culinary vessel, with the lamp in the centre, fixed in a frame, which may be taken out at pleasure as a distinct apparatus to afford light instead of heat. The wicks being incombustible, no snuffing or attention to them is requisite during the time of ignition; all that is necessary is to keep them free from dust when not in use, by screwing on a cap over each wick tube, and to put the plug in the central air-hole to prevent evaporation.

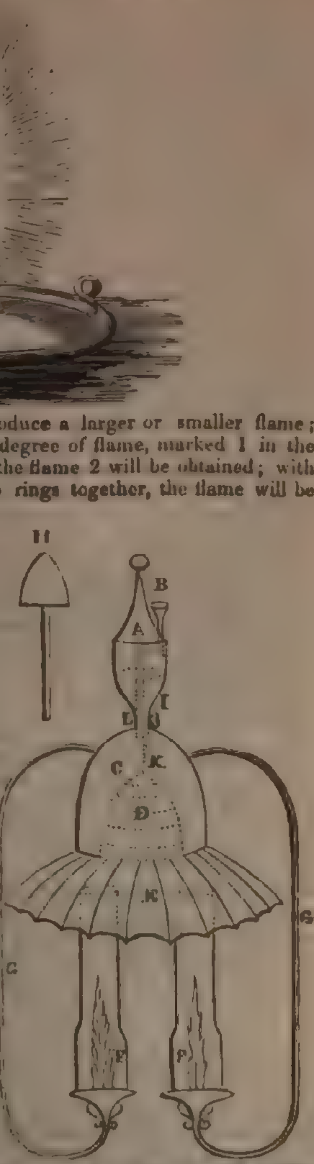
Mr. Blackadder, of Edinburgh, has also paid attention to the subject of lamps with incombustible wicks, and has given in the *Edinburgh Philosophical Journal* a description of several lamps of this description which he had contrived, some of which were well adapted for the combustion of essential oils, spirits of turpentine, &c. The burners he employed consisted of short pieces of bugle heads; some of these he inserted in pieces of talc, and found them to form a very convenient floating light when placed upon the surface of a portion of oil in a glass vessel. Mr. Blackadder's account of these lamps having called the attention of manufacturers to the subject, gave rise to the floating lights now in such general use as night lights, consisting of a short piece of capillary glass tube of very small diameter inserted in the bottom of a thin metallic dish or cup, and placed in a glass vessel containing oil. The cut in the following page represents an improved lamp of this description, which has this peculiar advantage over the ordinary ones, that it is capable of yielding four distinct degrees of flame, so that it may be accommodated to the occasion; a large

…er one being used according as convenient. This effect is produced by two small weights in the form of rings, fitted to lie in a recess at the … the floating dish; by the addition or removal of these weights the … of the dish is regulated so as to cause a greater or less flow of

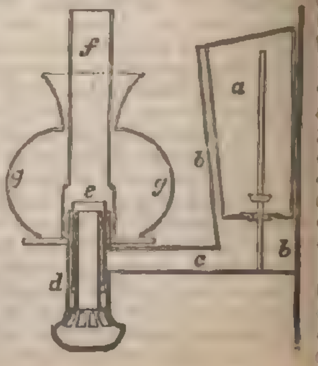


…gh the tube, and consequently to produce a larger or smaller flame; …th weights are removed, the lowest degree of flame, marked 1 in the … is produced; with the smallest ring the flame 2 will be obtained; with …est, the flame 3; and with the two rings together, the flame will be … that marked 4.

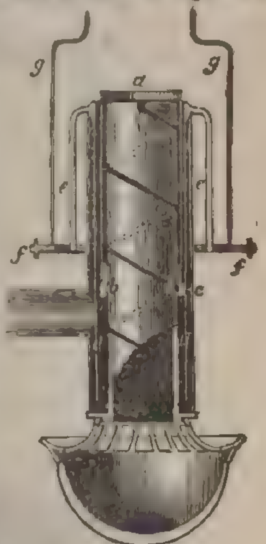
…xtract from the *Edinburgh Philoso-… Journal*, the following description of … generating gas lamp," a title which …lly applicable to every other kind of …re all generate the gas from which … is obtained; the difference is, that …amp the oil is decomposed and con-… into gas by falling on a substance …tly heated, and the gas is ignited as … from the orifice of a tube situated … the decomposing chamber, the heat … is maintained by the flame of …; whereas, in the ordinary lamps, … decomposed and ignited at the …int, viz. at the wick. "The oil … this lamp is represented at A., … tube by which the oil is admitted; … generator; D is a hollow vessel, … heat from the burners F, under-… collected; the dotted lines are … ridges on it within the gene-… prevent the oil running down and … at the bottom of the generator. …ular piece of iron to collect and … heat; G are tubes to conduct … from C to F; L is a tube to supply …cy in it with gas, as the oil is …d into C; H is a metal heater … D. To use the lamp, fill A par-…h oil, alcohol, or any fluid from which gas is produced, and having … metal heater H red hot, place it in the bulb D; after it has



continued in it a minute or two, turn the stop-cock I, allowing the fluid to drop slowly on the heated bulb D below, by which it will be converted into gas. When it is found to escape in sufficient quantities from the burners at F, set it on fire, remove the heater, and a beautiful bright flame will be supported by its own heat as long as there is oil in A; it may be found necessary to replace the first heater by a second, when the lamp is used for the first time, to expel more effectually the atmospheric air from the generator and tubes. The principle of this lamp is the same as that of Mr. Blackadder's (from which probably the idea was taken), viz. to decompose the oil by causing it to pass over an incombustible substance heated to redness; but the arrangements are more complex and not so efficient. Besides the objection to the detached heater, from the trouble of heating so large a mass, in comparison with the incombustible wick in Mr. Blackadder's plan, the decomposing vessel being of metal, will be found far inferior in effect to glass tubes or similar substances of inferior conducting power, and in a short time would soon become incapable of decomposing the oil, as it is found necessary at the Oil Gas Works to introduce into the retorts pieces of broken bricks, coke, &c., or plates of iron, which are renewed daily. The decomposing chamber D, and the circular rim E, both of which require to be situated over the flame of the lamp, are also highly objectionable, not only as cumbrous and unsightly appendages, but on account of the dark and extensive shadow which they would throw upon the ceiling. The size of wick must be proportioned to the degree of light the lamp is required to afford, but with the ordinary wicks, composed of cotton yarn slightly twisted, if the diameter be much increased, sufficient air does not arrive at the central part of the flame to cause the entire combustion of the fuel, and the lamp consequently burns with much smoke, and a deposit of carbonaceous matter upon the wick takes place; it is therefore found preferable to use two or more small wicks instead of one larger one. Count Rumford, whose experiments upon warming and lighting have produced such great improvements in these two branches of domestic economy, invented a lamp, the wick of which is formed of a kind of broad tape wove for the purpose; and, as a reading lamp, it is equal to any, whilst at the same time its construction is extremely simple: but the greatest improvement yet made in lamps, is the Argand lamp, so named from their inventor, M. Argand, of Geneva. The distinguishing feature of these lamps is that the wick is hollow or tubular, and the wick-holder is so constructed as to allow a passage for the air through the centre of the flame, as well as on the exterior, by which means every particle of the oil is decomposed and burned, and a most brilliant flame is produced, free from smoke or smell. When oil of the best quality is used, lamps of this description are found infinitely superior to all others for all situations where they do not require to be moved about, and are now manufactured in an endless variety of the most tasteful and elegant forms, and with various additional contrivances for regulating the height of the flame, the flow of oil, doing away with shadow of the oil vessel, &c. The annexed cut represents a very common and simple description of Argand lamp, adapted either to stand upon a bracket, or hang against a wall. In these lamps the oil surrounding the wick is maintained constantly at the same level, by a contrivance similar in principle to the bird fountain. *a* is the oil reservoir or fountain, closed at the top, but having an aperture at bottom fitted with a conical or button valve. The reservoir fits loosely into an outer case *b*, so as to allow free admission for the air between the two; *c* is the neck by which the oil flows into the wick-holder *d*, which is composed of two concentric tubes joined together at the bottom by a circular plate, having an aperture in its centre for

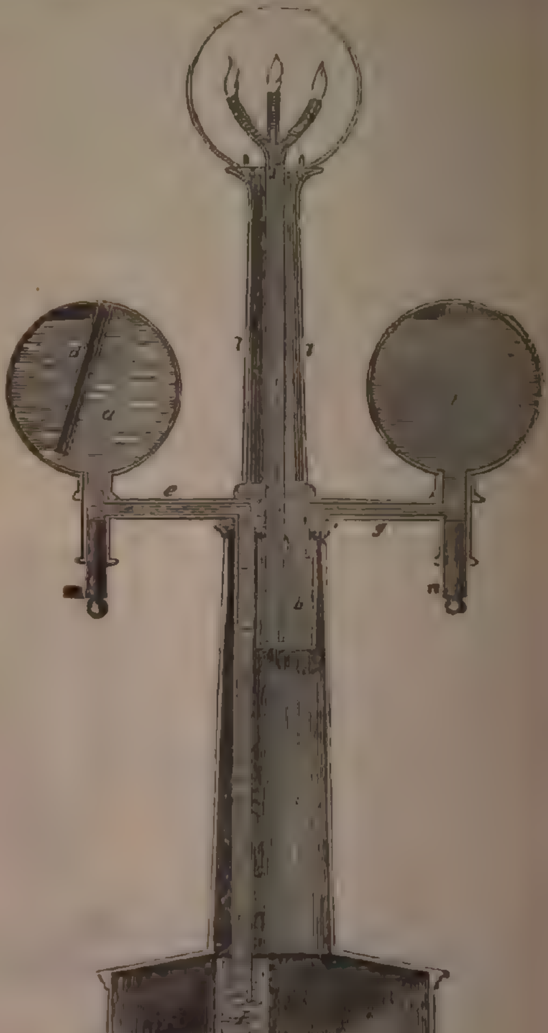


the passage of the air to the centre of the flame, equal to the aperture of the interior tube; *e* is the circular wick, fixed upon a ring, which can be raised or lowered at pleasure, by a contrivance which will require a separate diagram for its illustration. *f* is a glass chimney, to cause a more rapid current of air, and *g* is a ground glass shade, to equalize the light and soften the glare. To charge the lamp, the vessel *a* is withdrawn from the casing *b*, and, being inverted, the valve falls inwards, leaving the aperture open by which the oil is to be introduced. When the reservoir is filled, the aperture is closed by pulling up the wire or tail, projecting from the valve, and the reservoir may be returned to its erect position without any escape of oil. Upon replacing it within the casing *b*, before it quite reaches the shoulder of the case by which it is supported, the tail of the valve rests upon the bottom of the case, and the valve is pushed upwards, upon which the oil flows from the reservoir into the casing and wick-tube, until it touches the bottom of the reservoir, which descends a little below the level of the wick-holder, when the admission of the air into the reservoir being prevented by the oil in the casing *b* covering the aperture, no more oil can escape. Upon lighting the lamp, as the oil rises to the wick by its capillary attraction, the level falls in the casing *b*, and the aperture in the vessel *a* becoming uncovered, the air enters and expels a fresh portion of oil, until the level of the oil rises in the case and closes the aperture; and thus, during the time the lamp continues lighted, the oil in the casing and wick-holder is constantly maintained at the same level: a small cup *h* is screwed on below the wick-holder to receive any oil which may chance to overflow; care being taken that the cup shall be so far below the circular aperture of the wick-holder as not to impede the passage of the air to the flame. We shall now proceed to describe the means by which the wick is raised or lowered in order to regulate the flame. The adjoining figure represents a section of the wick-holder, except that part of the internal tube is shown entire in order to exhibit more clearly a spiral groove which makes two or three turns round it. *a* is the wick, the lower end of which is drawn over a small metal ring *b*, which has a small stud *c*, projecting each way, the internal end entering the spiral groove on the surface of the centre tube, and the external end passing through a longitudinal slit or groove, extending the whole length of a tube *d*, which is soldered into a ring, or collar, resting upon the top of the external tube of the wick-holder; from this ring, or collar, proceed the bent wires *e e*, which support the rim *f*, upon which the chimney *g* rests. Now, upon considering the figure, it will be seen that on turning the rim *f*, the tube *d*, which is connected with it by the bent wires *e e*, will also be turned round, and will carry with it the ring *b*, by its stud *c*; and as one end of the stud is engaged in the spiral groove, it will, in turning round, either ascend or descend along the groove, according to the direction in which it is turned: *h* is the tube by which the oil flows to the wick, and *k* is the cup to receive any overflowings.



When lamps are required to give light in one direction, as when placed against a wall, or used as reading lamps, the fountain lamps, similar to that just described, are undoubtedly superior to all others, on account of the abundant and uniform supply of oil which they afford to the wick; but when a lamp is required to throw a light all round, as when placed on a table in the centre of a room, the fountain becomes objectionable on account of the shade it throws; in this case the burner is usually mounted upon a column, and is encircled by a hollow ring at a distance of some inches from

it, containing the oil which flows to the burner by two tubes, and in orde the level of the oil may not greatly vary, the ring is made as flat as p This ring also supports a ground glass shade, which, besides softening the by its peculiar form, so reflects and refracts the rays in every direction as



to prevent any shadow being cast by the reservoir; hence these lamps are 'sinumbra," or "shadowless lamps." But although the shadow thro such lamps is scarcely perceptible, the light is not equal to that of fo lamps, owing to the supply of oil being neither so copious nor so uniform

the latter; and they are also somewhat cumbrous and awkward to move, owing to the projection of the reservoir and glass shade, and to the centre of gravity of the lamp being carried so high up. To remedy these defects has long been a favourite speculation with many persons, and generally every year one or more patents are taken out for lamps which are supplied with oil from a reservoir situated within the column which supports the burner. Few of these possess any claims to novelty, being most of them founded upon the principle of the Chremnitz fountain, in which a body of water descending through a given height forces a smaller quantity of water, contained in a close vessel, up to nearly an equal height by compressing the air above its surface. As illustrative of the principle we shall describe one or two of these lamps, although as we have already remarked, few of them exhibit much originality of thought. The figure on page 36 represents an arrangement for a lamp described in the *Register of Arts* as the invention of a correspondent in which the resemblance to the Chremnitz fountain will be at once recognised. *a* is a vessel containing water; *b* an oil vessel; *c c* a column and pedestal to support the lamp, closed at the top and bottom, and forming the air vessel; *d* an air tube in *a*, open at top and bottom; *e* a tube soldered into the top of the column *c*, and proceeding from the bottom of *a* to the bottom of cup *f*; *g* a similar tube soldered to *c*, and proceeding from *b*, the lower end descends a little way into the cup *h*; *i* is a glass tube ascending from the bottom of the cup *h*, through a tight joint, and branching at top into three capillary jets, forming the burner, and the tube *l*, which surrounds it, serves to receive any oil that may flow over; *m* and *n* are two plugs in the bottom of *e* and *g*. To use the lamp proceed as follows:—Invert the lamp, withdraw the plugs *m* and *n*, fill *a* with water, and *b* with oil, then replace the plugs in the position shown in the drawing, and place the lamp on its base. The oil will now flow from *b* into *h*, until the mouth of the tube *g* is covered; at the same time the water flowing from *a* into *f* will compress the air in *c*, which, acting on the surface of the oil in *h*, will force it up the tube *i* to the burners; by this the oil in *h* will fall below the mouth of *g* when a portion of the compressed air passes into *b*, displacing an equal bulk of oil; by these means the oil in *h* is always maintained at the same level as the mouth of *g*; the capacity of *a* is not equal to that of the base up to the level of the brim of the cup *f*; but it is clear that by means of the air-tube *d*, the height of the column of water will always be equal to the height of the lower opening of *d*, above the brim of *f*. To extinguish the lamp, push the plugs *m* and *n* into the necks of *e* and *g*, which stops the supply of oil. The cup *f* is screwed into the bottom of *c*, and must be unscrewed to discharge the water in *c*, when the vessel becomes empty.

In the sketch on page 38, *Fig*. 1, represents a section of a lamp invented by Mr. Bright, of Bruton Street, which was exhibited at the National Repository, and which we have seen in use elsewhere, and it appeared to us to afford a strong and steady light. The principle is precisely similar to that of the one just described, but it is much more compact, and the general arrangement is better. This lamp, and the mode of its action, may be briefly described as follows:—The water vessel *b* is an inverted fountain, which empties itself into the air chamber *c*, through the pipe *d*; the air thus displaced is forced up the rising bent tube *e* into the oil vessel *a*, from whence, as it cannot escape, it presses upon the oil and forces it up the pipe *f* to the burner *g*. It will be seen that by this arrangement the two columns of oil and water will be constantly in equilibrio.

The last lamp upon this static principle which we shall notice, differs somewhat from the preceding, and possesses rather more novelty. It is represented in section on p. 38, *Fig*. 2, and the following is an extract from the inventor's description of it in the *Register of Arts*:—*a* a glass vessel forming the body of the lamp; surmounted by a glass column connected with *a* by the cork *c*, which fits tightly into each, and closed at top by the cork *h*. No. 2 a glass tube descending through the two corks *h* and *c*, to the bottom of the vessel *a*, and bent upwards again as far as *g*, it communicates with the column by the hole *f*, which may be closed by a sliding tube 5, and the latter be closed by the stopper *k* at its top. No. 1 a glass tube passing through the corks *h* and *c*, its lower end opening

into *a*, and its upper connected by a stop cock with *d*, a glass vessel c at top and bottom with corks. *e* a capillary tube descending half way do No. 3 a tube passing through *h* and *c*, and reaching to the bottom it has two small openings into the column in its upper part, which ma closed by the stopper *l*. No. 4, (not seen in the section, but shown in F which is a plan of the tubes,) is a tube passing through *h* and *c* into the u part of *a*. The mode of filling the lamp is as follows: close the hole *f* in N

Fig. 3.

Fig. 1.

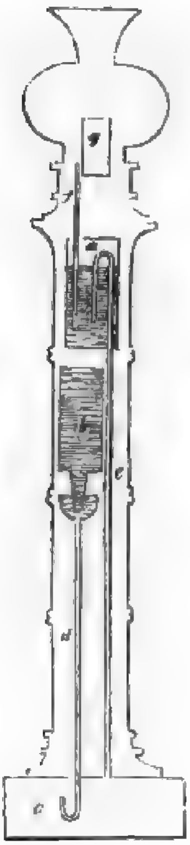
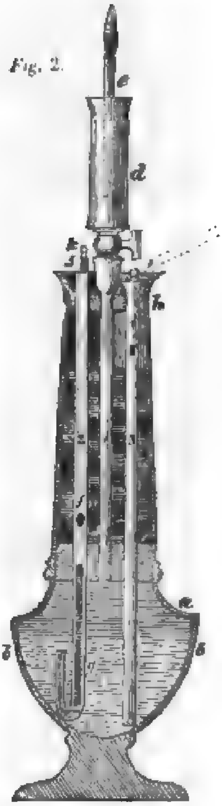


Fig. 2.



and open 1, 2, and 3, and through 5 pour quicksilver till *a* is filled to the le the top of the bent leg *g*, then close 5 by its stopper *k*. In the top of 3 a bent tube, (shown by the dotted lines,) and suck the air out of the co when the mercury will rise in 3, pass through the holes in its upper end occupy the space shown by the dotted lines. Remove the bent tube

stopper *l*, and through 4 pour water into *a*, up to the line *b b*, and the cock *c*, and close No. 4, and the operation is complete. When the ...anted for use, take the stopper out of No. 5, and raise 5 till the hole ... open, when the mercury will descend and pass over *g* into the bottom ...ng the oil up No. 1 to the burner *e*, to which a light being applied, it ...nue burning steadily till the oil in *a* and the mercury in *i* are ex... when the lamp is to be refilled by exhausting the air in *i*, and pouring ...h No. 4. The flame may be regulated or extinguished by means of ...ock. The height of *e* above *g* may be equal to, but must not exceed, column of oil, whose pressure shall be equivalent to the pressure of ...n of mercury.

...he foregoing description, it will be seen that the columns of oil and ...y always maintain their respective heights, and the supply of oil ...rner is consequently always uniform. The inventor states, that the ...ich was merely got up for an experiment) afforded a steady light ...

...amp which is represented in section in the annexed engraving, and the invention of R. F. Jenour, the air is compressed in a closed by means of a condensing ...d a communication being ...tween the air chamber and ...mber, the air by its expan... the oil up the supply pipe ...rner. The body of the ...vided into three compart... two discs, *a* and *b*; *c* is the ..., *d* a space to receive the ...gs from the burner, and *e* ...essel; *f* is a condensing ...e piston rod of which *g* is ...he lower end of the syringe ...y a valve *h*, pressed against ...gs; a rod from this valve ...ugh *g*, and can be screwed ... nut *k*; *l* is a tube connect... vessel *c* with the air vessel ...as another aperture to the ...e, closed by the nut *m*; *n* is ... for supplying the burner, ...capillary tube *o*, cemented ...er end, which descends to ... of the oil vessel; *p* is a ... for cutting off the commu... with the burner, which being ...mmon description is not ...The middle compartment *d* ...the atmosphere by a short ...rrounding *n*; *r* is a tube ...to *c*; it is pierced with ... holes at the lower end, ...ed by a valve which is

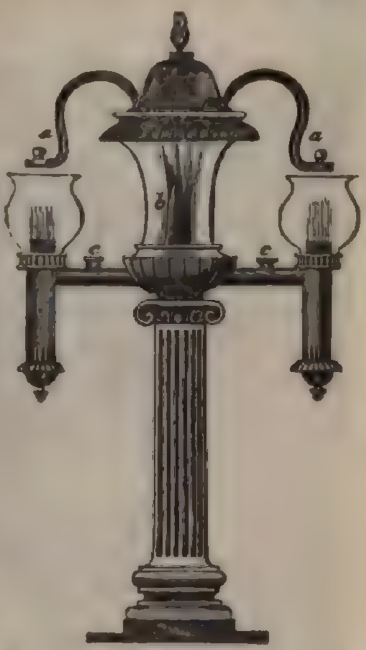
... a nut *s* screwing on to the top of a rod attached to the valve; *t* an ...scending from the top of *e* to the bottom of *c*; the air, therefore, ...ough the oil in *c*, and collects above its surface and in the air vessel ...rge the lamp with oil unscrew the nut *m*, and slacken the nut *s*, ...n oil by the tube *q*, and it will descend into *c* through the holes in *r*; ... and *s* must then be screwed down again. The nut *k* must now be ... from the rod of the valve *h*, and the air injected by the syringe, ... to close the orifice of the piston rod, by applying the finger to it ...ke; when the resistance against the valve increases, till the syringe

can no longer be worked, the nut *k* must be again screwed on, and the l[...] ready for use, by merely opening the stop-cock *p*. There have been [...] lamps upon the principle of the one just described, but from the diffic[...] regulating them, they have not come into general use; this difficulty ar[...] part from the continually varying pressure of the condensed air, occasion[...] its increase of volume as the oil consumes, and also from the difficu[...] regulating the supply of oil to the burner, so as neither to overflow n[...] short of what is required. In a lamp invented by Mr. Machell, a pl[...] cotton is introduced through the bore of a cock, when, by turning the plu[...] passage may be regulated with considerable accuracy. In the present [...] the patentee effects this by a capillary tube, which retards the flow of [...] proportion as it is lengthened, and this is the principal improvement clai[...] the patent. The objection to this seems to be that the flow cannot be reg[...] at pleasure. Upon the whole, although many of the lamps with the oil [...] voir contained in the base, exhibit considerable ingenuity in various pa[...] their details, yet very few have been found to answer in practice, being [...] either troublesome to manage, or unequal in their action; and the only [...] of this description which we have yet seen which seems to be of decided [...] tical utility is one of French invention. In this lamp there are two [...] pumps worked by a train of clock-work situated beneath the reservoir [...] in the pedestal of the lamp. These pumps, which in their construction re[...] a pair of bellows, work with very little friction, and impel the oil in a c[...] stream to the burner, and no inconvenience can result from an excess [...] supply as the overflow merely returns into the reservoir.

We shall now proceed to notice one or two lamps adapted to the burn[...] concrete oils and solid unctuous substances, as fat, tallow, butter of cacao, [...] the purpose of illumination these substances are on a par with oil, afford[...] equally brilliant light and at a much less cost; but in order to burn the[...] lamp it is requisite previously to render them fluid, and to maintain [...] in that state so long as the lamp is in use. Various arrangemen[...] employed for this purpose, but the principle is the same in all; viz. to co[...] portion of the heat arising from the flame of the lamp to the combustible [...] by means of some good conductor, as an iron or copper tube or wire inserted in the combustible mass, and coming in contact or nearly so with the flame. A very simple lamp of this description is exhibited in the annexed cut; *a* is the fat rendered fluid, lying in the body of the lamp; (the cover of the lamp being removed to show the interior;) *c* is a small tube to convey air into the middle of the flame (to perfect the combustion, on the principle of the Argand burner); this tube opens at the lower end into the large tube *b*, as shown by dots; a small perforation is also made at *d*, to allow the air to flow freely into the tube *c*, when the lamp is fixed in the socket of a candlestick. On each side of the air tube a short piece of copper pipe is fixed by hard solder, for holding the cotton wicks; these tubes (which ought to be longer) get intensely hot, and, by the conducting power of the metal, the heat is transmitted to the fat, which, melting in consequence, flows up the wick like fine oil, but infinitely preferable, on account of its diffusing no unpleasant smell during the combustion.

The Hon. E. Cochrane obtained a patent for a lamp, named by hi[...] "Patent Dissolvent Lamp," which, like the one just described, is calcul[...] burn tallow and concrete oils. These lamps, which have been very exte[...] manufactured in a variety of elegant forms by Mr. José, of Regent-street, [...] an extremely brilliant light at a very small cost. The engraving and d[...] tion in the following page will explain the principle of these lamps. *a a* [...] solid bent metal rods that conduct the heat received from the flame of the l[...]

tallow contained in the reservoir *b*; the ends of these conductors are therefore made to descend to the bottom of the reservoir; *c c* are two apertures (with covers that screw on) made in the supply pipe, for the purpose of pouring in a small quantity of melted tallow upon lighting the lamp, after which the heat from the combustion being conducted into the reservoir, the supply of fluid tallow is uniformly kept up until it is all consumed.



We extract from a printed circular of the manufacturer the following observations on the advantages attending the use of these lamps:—"To those acquainted with the superior combustible properties of tallow and cocoa-nut oil, it is unnecessary to say more than that these lamps effectually melt and burn both, and that the price of the latter, at the manufactory, is 2*s.* 6*d.* per gallon; but to others, to whom their good qualities are less known, it is necessary to state, that from the comparatively small portion of oxygen necessary to complete their combustion, the total absence of smoke and smell is insured, and the brilliancy of the flame is such as no lamp ever before produced, and nothing but the best gas-light can equal. To families who kill their own meat, innkeepers, proprietors of cook-shops, &c. &c. a two-fold advantage will be found in the use of these lamps, as it is not merely tallow that they burn, but grease of every description, such as dripping, pot skimmings, &c. &c., a pound of which, value about 3*d.*, will continue to burn for full twelve hours in a common-sized dissolvent Argand burner, to yield light equal to eight candles, being no more than a farthing an hour."

The following ingenious plan for a lamp to burn under water appeared in the *Register of Arts*, in connexion with a diving apparatus, for examining the breaches in the Thames Tunnel, and might very often be of service in the diving bell, when the water, as is frequently the case, is so disturbed that sufficient light is not refracted through it at great depths to permit accurate examination. A spherical or cylindrical vessel is to be provided, similar to the vessels containing the portable gas for burning; into this a few atmospheres of pure oxygen are to be condensed by a syringe, through a valve at the bottom: a short jet tube is then to be screwed into the top of the vessel. A lantern, with a strong and powerful reflector, must be attached to the upper part of the vessel containing the condensed oxygen, permitting the jet tube to enter the lantern. The top of the lantern must be provided with a screw cap; a piece of wax candle may be advantageously employed for the light. It is needless to say that the apparatus must be air and water tight. Immediately before use, pour into the lamp a solution of caustic alkali, potash or soda, and screw on the cap; then turn the cock gently to admit a sufficient quantity of oxygen through the jet tube, to support the combustion of the candle. The products of the combustion will be carbonic acid and water; the former will be absorbed by the alkaline solution as it is formed, and the latter will be condensed by the sides of the lantern; the oxygen admitted will unite with the nitrogen of the

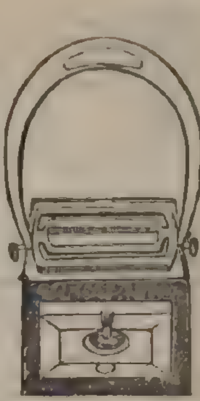
air of the lantern (which is not consumed), and will form a supply of ordinary atmospheric air.

The annexed figure represents a lamp as constructed by the inventor, which, upon trial, was found to answer very well.

Reference to Engraving.—*a*, the vessel of condensed gas; *b b*, the reflectors placed at suitable angles to accumulate the light upon a bull's eye magnifier fixed in front, but removed in the drawing to show the interior of the lantern; *c*, the screw cap of the lantern; *d*, the alkaline solution; *e*, the jet pipe; *f*, portions of the shield frames of the tunnel; *h*, accumulation of mud and earth as it may be supposed to have entered the tunnel.

The cut on p. 43, represents one of the many ways in which the "march of

mind" in the present day accelerates the march o the body; the subject is a "stirrup lantern," intended, in the words of Scripture, as a "light unto our feet, and a lamp unto our paths." The stirrup lantern is a small square lantern, fixed at the bottom of a stirrup by means of two screw rings on each side, as exhibited in the drawing, and by unscrewing them, the lantern may be detached from the stirrup when requisite. The lamp part is so contrived that no oil can be spilt, nor the steady light which is thrown across the road before the horse's feet be at all impaired by any motion of the horse. The front part, as shown in the drawing, is of glass, through which is seen the lamp, burner, and wick; behind, there is placed a reflector for transmitting the light to the front. It is supplied with a constant current of air, by means of apertures, in a sort of double casing, which is so disposed as to prevent any gust of wind from extinguishing the light.



Amongst the numerous contrivances for rendering lamps ornamental, is a very singular one, which we must briefly notice: it consists in surrounding the light by screens of ground glass, on which are painted various elegant devices, these screens are suspended upon a fine pivot, in the same way as a common chimney cowl, and have fixed across their upper orifice a number of oblique vanes or fans; and the current of heated air from the lamp, impinging upon these vanes, imparts to the screens a slow rotatory motion. The pleasing effect of crystal chandelier ornaments in refracting the rays of light is well known; but the chandelier makers have hitherto principally devoted their attention to increasing the number of reflecting and refracting surfaces without paying much regard to their form, magnitude, or position with respect to each other. M. Osler, of Birmingham, however, has lately introduced a great improvement in this branch of the subject; instead of a great number of detached crystal drops, he forms a complete casing for the light by ranging a number of square or triangular prisms in a cylindrical or conical figure, the sides of the prisms touching each other, and their ends being connected by various ingenious means, for which he has a patent. The effect thus produced by the large surface of the prisms is exceedingly brilliant and splendid.

We shall conclude this article by a description of that admirable invention of Sir H. Davy, the "safety lamp," by the aid of which the hazardous occupations of the miner are now carried on with considerably less difficulty, and with infinitely less danger, than before this invention The gases extricated in mines (which are destructive to animal life) are of two kinds, and are by the miners called the *choak damp*, and the *fire damp*; the former consists for the most part of carbonic acid gas, hovers about the lower parts of the mine, and extinguishes their lights; and the latter, which is simply hydrogen gas, occupies the superior spaces, and involves incalculable mischief, from the combustion produced by its contact with the flame of the miners' candles. The consequences resulting from the frequent explosion of this inflammable air, have been lamentable and tremendous in the highest degree; and whilst a source of the greatest terror to the persons most intimately affected by its operations, it has excited the deepest sympathy and commisseration in the general mind. To remove an evil so dreadful in its nature, Sir H. Davy applied his energetic and comprehensive mind to the discovery of some means by which these saddening calamities might be averted, and after numerous experiments, devised the safety lamp, an invention that must ever rank him high among the benefactors of mankind.

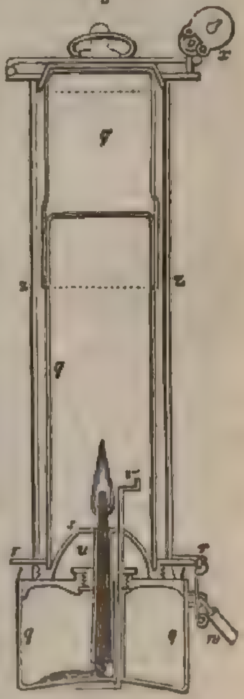
To afford a clear idea of the nature of the lamp, we shall avail ourselves of the language of Dr Ure, who has treated it, and the points relatively consequent upon it, in a very masterly manner. "In the parts of coal mines where danger was apprehended from fire-damp, miners had been accustomed to guide themselves,

or to work, by the light afforded by the sparks of steel struck off from a wheel of flint. But even this apparatus, though much less dangerous than a candle, sometimes produced explosions of the fire-damp. A perfect security from accident is, however, offered to the miner, in the use of a safe lamp, which transmits its light, and is fed with air, through a cylinder of iron or copper wire gauze; and this fine invention has the advantage of requiring no machinery, no philosophical knowledge to direct its use, and is made at a very cheap rate. The apertures in the gauze should not be more than 1-20th of an inch square. As the fire-damp is not inflamed by ignited wire, the thickness of the wire is not of importance, but wire from 1-40th to 1-50th of an inch in diameter is most convenient. The cage or cylinder should be made by double joinings, the gauze being folded over in such a manner as to leave no apertures. When it is cylindrical, it should not be more than two inches in diameter; for in larger cylinders, the combustion of the fire-damp renders the top inconveniently hot; and a double top is always a proper precaution, fixed one-half or three-fourths of an inch above the first top. The gauze cylinders should be fastened to the lamp by a screw of four or five turns, and fitted to the screw by a tight ring. All joinings in the lamp should be made with hard solder; and the security depends upon the circumstance, that no aperture exists in the apparatus larger than in the wire gauze." The parts of the lamp are—A, the brass cistern which contains the oil, pierced near the centre with a vertical narrow tube, nearly filled with a wire which is recurved above, in the level of the burner, to trim the wick, by acting on the lower end of the wire, with the fingers: it is called the safety trimmer. B, the rim in which the wire gauze cover is fixed, and which is fastened to the cistern by a movable screw. C, an aperture for supplying oil, fitted with a screw or cork, and which communicates with the bottom of the cistern by a tube; and a central aperture for the wick. D, the burner, or receptacle for the wick, over which is fixed the coil of platinum wire. F, the wire gauze cylinder, which should not have less than 625 apertures to the square inch. G, the second top, three-fourths of an inch above the first, surmounted by a brass or copper plate, to which the rings of suspension are fixed. I, I, I, six thick vertical wires, joining the cistern below to the top plate, and serving as protecting and strengthening pillars round the cage. When the wire-gauze safe lamp is lighted and introduced into an atmosphere gradually mixed with fire-damp, the first effect of the fire-damp is to increase the length and size of the flame. When the inflammable gas forms as much as 1-12th of the volume of the air, the cylinder becomes filled with a feeble blue flame, but the flame of the wick appears burning brightly within the blue flame, and the light of the lamp augments, till the fire-damp increases to one-eighth or one-fourth, when it is lost in the flame of the fire-damp: which in this case fills the cylinder with a pretty strong light. As long as any explosive mixture of gas exists in contact with the lamp, so long it will give light; and when it is extinguished, which happens when the foul air constitutes as much as one-third of the volume of the atmosphere,

the air is no longer proper for respiration; for though animal life will continue where flame is extinguished, yet it is always with suffering. By fixing a coil of platinum wire above the wick, ignition will continue in the metal when the lamp is itself extinguished; and from the ignited wire, the wick may be again rekindled in going into a less inflammable atmosphere. In a letter to the Royal Society, dated Newcastle-upon-Tyne, Sir H. Davy says, "All the la

that I have examined, have at different times been red-hot, and a workman at the Hepburn Colliery showed me a lamp, which, though it had been in use about sixteen hours a-day for nearly three months, was still in excellent condition; he also said it had been red-hot, sometimes for several hours together. Wherever workmen, however, are exposed to such highly explosive mixtures, double gauze lamps should be used; or a lamp in which the circulation of the air is diminished by a tin plate reflector, placed in the inside; or a cylinder of glass, reaching as high as the double wire, with an aperture in the inside; or slips of Muscovy glass may be placed within this lamp; and in this way the quantity of fire-damp consumed, and consequently of heat produced, may be diminished to any extent. Such lamps, likewise, may be more easily cleaned than the simple wire gauze lamps; for the smoke may be wiped off in an instant from the tin plate or glass. If a blower or strong current of fire-damp is to be approached, double gauze lamps, or lamps in which the circulation of the air is interrupted by slips of metal or glass should be used, or if the single lamp be employed, it should be put into a common horn or glass lantern, the door of which may be removed or open."

Fig. 1.



Notwithstanding the increased security afforded by the safety lamp, coal miners are slow to avail themselves of it, owing to the inferior degree of light it affords compared with that given by a naked candle. This arises from two causes, viz. the necessary obstruction offered by the black wire, of which the cage or gauze is composed, within which the lamp is placed; and the casual obstruction occasioned by the adhesion of smoke to the inside of the cage, when the lamp is not carefully trimmed, and of smut and dust to the outside of the cage.

To obviate these objections, Mr. Roberts, of St. Helen's, Lancashire, has introduced some modifications and improvements in the construction of the safety lamp, for which he has received a reward from the Society of Arts. To diminish the obscuration occasioned by the first cause, Mr. Roberts proposes that the wire shall be kept bright and polished, by cleaning the cage every night with a soft brush, and the black powder, or smut, which occurs in all coal mines, especially in the neighbourhood of faults; this smut is pulverulent non-bitumenous coal, sufficiently hard to remove the rust from the surface of the wire, without materially wearing the wire itself. As the lamp is at present constructed, the oil will run out of the cup or receptacle in which it is placed, if the lamp is laid in a horizontal position, an accident which frequently occurs on account of the lamp being rather top heavy. When this happens, the gauze becomes smeared over with viscid oil, which causes the coal dust floating in the air of the mine to adhere to it, and in a short time to fill up, more or less, the meshes of the gauze. By merely shaking or tapping the lamp, the dust will not be dislodged; and if the miner attempts to clear his lamp by blowing through the wire gauze, he runs the risk of putting out the light, and, after all, very imperfectly clears the meshes; there is also, perhaps, some risk of forcing the flame through

Fig. 2.

the meshes on the opposite side, and of producing an explosion, if the surrounding air is inflammable. In Mr. Roberts's lamp the overflow of the oil is impossible, on account of the dome-shaped cover which surrounds the wick; the dust, therefore, that settles on the gauze may be dislodged by a mere tap of the finger, or what would perhaps be better, by the application of a small brush similar to that which soldiers carry to clear the pan of their muskets, and which might be attached by a bit of small chain to the handle of the lamp. *Fig.* 1, on the preceding page, represents a section of the lamp *p p*, and wire gauze *q q*; *r r*, a screwed cap, with a hollow dome *s*; it screws into the neck, *t t*, of the lamp; the dome rises a little above the neck holder *u*, having an opening at top to let the wick and trimming wire *v*, rise through. This dome serves to catch and retain any oil that may be spilt by shaking the lamp, or knocking it over, thereby protecting the wire gauze *q* from being smeared: *w* and *x*, two locks, the former to secure the cap *q*, and the latter to secure the wire gauze *q* from being removed. *Fig.* 2, a section of the cap and dome, *r r s*, separate from the lamp; the wire gauze fits into the cavity *y y*, around the dome *s*; *z z*, two of the four wires which serve to hold the wire gauze.

Mr. Bonner, of Monkwearmouth, Durham, has a patent for an improvement upon the safety lamp, which consists in a means of increasing the light of the lamp, and also of extinguishing it instantaneously. The mode of increasing the light is as follows:—Instead of introducing a wick in the centre of the lamp, as is usually practised, he introduces a series of small wicks round a centre tube, and by lighting one, two, or more wicks at a time, little or much light is obtained. The means of instantly extinguishing the light consists in a metal cap, or extinguisher, suspended within the wire gauze tube by a pin or catch; upon withdrawing the pin the extinguisher falls over the wick and the light is put out.

In Mr. Murray's safety lamp the wire gauze tube is suspended by two concentric tubes of strong glass, the space between the two tubes being nearly filled with water; by this means a much greater degree of light is obtained, but we are not sure that the risk is not also greater than when a wire gauze tube is employed.

LAMP-BLACK. See Black.

LANCET. A two-edged and pointed surgical instrument, chiefly used for opening veins in the operation of bleeding.

LANTERN. A transparent case to contain a light. Lanterns are of various kinds adapted to their peculiar uses; most of them are, however, too well known to need a description here. The dark lantern is so called from the circumstance of the light being entirely screened from observation at pleasure, by means of a door or sliding shutter, that covers its only aperture for the transmission of light. See Lamp.

Lantern, Magic, is an amusing optical machine, whereby painted objects upon glass placed between lenses, become considerably magnified in their shadows, which are projected against a whitened wall or screen. The lantern is inclosed so that no light can pass out of it, except through a double convex or plano-convex lens; around the circumference of this lens is fixed one end of a tube that projects from the lantern; the fine end of this tube receives another smaller tube which slides in it, and carries at its remote extremity a double convex lens. On the fixed tube between the two lenses, lateral apertures, or vertical slits are made, through which the objects painted on slips of glass are slided. The objects are thus illuminated, and their form and colours, on a magnified scale, transmitted with the light upon the screen.

The optical delusion termed Phantasmagoria, is produced by a similar machine to the magic-lantern; but instead of the figures being painted on transparent glass, all the glass is rendered opaque except the figure, which is painted in transparent colours, the light therefore shines only through the figure, which is thrown upon a very thin screen of silk placed between the spectators and the lantern; and it is by moving the instrument backwards or forwards, that the figures appear to recede or approach.

LAPIDIFICATION. The art of cutting and polishing stones as practised

by lapidaries. The stone to be cut is cemented to the end of a stick, and the different facets or planes on its surfaces are formed by a little simple mill contrived for the purpose. In India the mill is made of a mixture of lac resin and emery (or corundum) by melting one part of the former, and then mixing two of the latter with it by degrees; and, subsequently, well beating and rolling the paste to give it solidity, and the required form. In this country, the soft metals, such as fine copper, or the alloys of tin and lead, are used as the substance for the mill or grinding-wheel; in the surface of which is impressed diamond dust, emery powder, or other suitable abrading or polishing powders. The mill is made to revolve horizontally. Near to the mill is fixed a thick upright peg of wood, called a guage, which is pierced with small holes in all directions, and the process of forming the facets thus takes place. The stone at one end of the stick is applied to the surface of the mill, and the opposite end of the stick is inserted into one of the holes of the guage; in this position it is kept steady by the workman with his right hand, whilst he gives motion to the mill by his left. The skill of the lapidary is exercised in regulating the velocity of the mill, and on the pressure of the stone against it, with an almost imperceptible tendency to one or other direction in different stages of the work, examining each facet at very short intervals, in order to giving as great precision as possible to its size and form. The cutting being completed, the polishing is effected by changing the mill-wheel for another usually made of brass, the surface of which is charged with fine emery, tripoli or rotten-stone, by the successive use of which the facets are perfected and brightened.

LATCH. A simple fastening to doors. The original and simplest form of a latch, is the little falling bar hooked, and the catch; the former being fixed on the door, and dropping into a notch of the latter, which is fixed to the door-post. On the opposite side of the door such latches were formerly lifted by a string passing through the door, or by a finger inserted through a hole under the latch. In process of time a little lever was made to perform this office, and next to the lever was added a bowed handle. This very useful combination now goes by the name of a *thumb latch*, and such are our facilities of manufacture, that millions of these are made annually in the neighbourhood of Birmingham, and rendered to the dealers at prices averaging not more than three half-pence each. The work people, are, however, very inadequately remunerated for their valuable labour. Thumb latches of a more massive and finished description, with round black varnished handles, are distinguished from the former by the term of *Norfolk latches*. For the inner doors of houses a variety of spring latches are extensively used termed *bow latches*, (which are those on square plates with brass knob or ring handles,) and *long latches* (chiefly distinguished from the other by the length and form of their plates). Some of these are made without handles, and keys are employed to open them externally, but wherever elegance or neatness is studied, *mortise latches* are used; these are let into the thickness of the door in the manner of mortise locks, and nothing is visible on either side of the door but an ornamental handle; the folding windows called French sashes are usually provided with them. There is another kind of latch which affords all the security of a lock, with numerous wards, termed the *French latch*. A small, but broad, flat key, having numerous wards cut out of a solid plate of metal, is passed through a narrow horizontal perforation in the door (covered with a suitable escutcheon), whence it enters the body of the latch; the key being then merely lifted upwards, the solid wards of the latch pass through the interstices of the key, permitting the latter thus to unlatch the door.

A very simple and convenient common latch, well adapted to stable doors, was recently invented by Mr. T. N. Parker, of Sweeny, which we will take leave to call the *pull latch*, as it may be opened on either side of the door by a pull. It is represented in the cut on the following page; *a a* is a curved piece of iron like the letter *S*, which turns upon a joint at *b*, and passes through a hole in the door at *c*, and supports the latch *d*, which is inclosed by the usual keeper *e*. On one side of the door the curved hook *a* acts as a lever of the first class

in lifting the latch; while in the other the curved hook *a* acts as a lever of the second class for the same purpose. The common lever is thus converted into two handles besides performing its own office.

LATHS are long, thin, and narrow slips of wood nailed to the rafters of a roof to sustain the covering, or to the joists of a room, in order to support or hold up the plaistered ceiling; they are also used for light fencing and various other purposes. Laths are usually made by rending them out of fir or oak; they are made of various lengths, from 2 feet to 4 feet, and are distinguished by three different thicknesses, termed single, lath and half, and double; the latter signifying double the thickness of the single, and lath and a half the medium thickness. In the United States of America, where manual labour is at present more scarce than in this country, machinery has been employed for rending as well as for sawing out laths: there is nothing n[illegible] in the latter operation, but there is apparently something worthy of no[illegible] our countrymen in the annexed reports of American patents, which we [illegible] from the *Franklin Journal* of Philadelphia.

In Rice's machine, "a stock is fixed in a frame, in which it slide[illegible] backward and forward; it is moved by a cog-wheel, which works in [illegible] one side of the stock in the manner of a rack and pinion. A knife i[illegible] upon the stock, and the timber to be cut into laths, &c. is fixed in a fram[illegible] is made to bear against the stock, and the lath is cut by the traversing [illegible] of the stock. The knife, it is said, may have a double edge, so as to cu[illegible] both by the forward and backward motion."

Lynch's machine "consists of a long plank, which operates as a plane [illegible] this plank is made to slide upon its edge between upright standards upon [illegible] platform; a wide iron, like a plane-iron, is fixed so as to cut on one face [illegible] plank much in the manner of the cutters of some shingle machines; the [illegible] of the plane, if we may so call it, has other cutters standing at right [illegible] with the first cutter, and at such distances apart as to reduce the la[illegible] proper width. The cutter plank is made to traverse by means of a pit[illegible] one end, operated upon by any suitable power."

LATHE. A machine chiefly used for giving a truly circular form to [illegible] metals, and other substances. See TURNING.

LEAD. A metal of a bluish-white colour, and when recently cut, o[illegible] siderable lustre. It is very soft and flexible; not very tenacious, and [illegible] quently incapable of being drawn into very fine wire; yet its mall[illegible] permits it to be extended, either under the hammer or the rollers, in[illegible] thin sheets. Its specific gravity is 11.35; it soils paper and the fin[illegible] friction, imparting a slight taste and a peculiar smell: it is a good condu[illegible] heat; melts at 612° Fahr., and when cooled slowly, crystallizes into quadr[illegible] pyramids. Lead is brittle at the time of congelation, and may then be br[illegible] pieces with a hammer. Although the brightness of fresh cut or scraped le[illegible] goes off, it does not alter much by exposure to the air; owing, it is su[illegible] to a thin film of oxide being formed upon its surface, which defends th[illegible] from further corrosion; this property renders it peculiarly suitable [illegible] gutters and coverings of buildings. Lead ore is found in most parts [illegible] world. In Britain, the principal lead mines are situated in Cornwall, [illegible] shire; in Northumberland, Westmoreland, Cumberland, Derbyshire, D[illegible] Lancashire, and Shropshire; in Flintshire, and various parts of Wales; [illegible] several districts of Scotland. The smelting is performed either in a b[illegible] nace, called an "ore hearth," or in a reverberatory furnace. In the [illegible] method the ore and fuel are mixed together and exposed to the action [illegible] blast, which quickly fuses the metal and causes it to fall into the lower [illegible] the hearth, where it is protected from the oxygen of the blast by th[illegible] that floats upon its surface. When the fluid lead is tapped, a [illegible]

quantity of it is left in the furnace to float the liquid scoriæ; but when the whole of the lead is to be drawn off, the blast is stopped, and some lime is thrown into the furnace to concrete the scoriæ whilst the lead is run out. In smelting by the reverberatory, which is undoubtedly the best, the fire is made at one end, and the flame passes over the hearth and enters into an oblique chimney, which terminates in a perpendicular one, called a stock, of considerable height. The length of the hearth, from the place where the fire enters to the chimney, is about 11 feet, 2 feet of which constitute the throat of the furnace; the remainder forms a concave surface, 4½ feet wide at the throat of the furnace, and rather more than 7 feet at the distance of 2 feet from the throat, about 7 feet in the middle of the hearth, and 6 feet at 2 feet distance from the chimney, and nearly 3 feet where the flame enters the chimney, which it does through two apertures, each 10 inches square. The throat of the furnace is 2 feet long, 4 feet wide, and 6 inches deep. The length of the fire-place is 4 feet, equal to the width of the throat; its width is 2 feet, and depth 3 feet from the grate to the throat of the furnace; the section of the oblique chimney is 16 inches square, and of the perpendicular 20 inches, supposing a straight horizontal line drawn from the lower plane of the throat of the chimney to the opposite side of the furnace; the lower part of the concave hearth, which is in the middle of this cavity, is 19 inches below this line, the roof of the furnace being 17 inches above the same line; the rest of the hearth is conformably concave. The furnace on one side has three openings, about 10 inches square, at equal distances from each other, and provided with iron doors, which can be removed as occasion may require. Besides these apertures, which are for the purpose of raking and stirring the ore, &c., and consequently upon a level with the horizontal line before alluded to, there are two others of smaller dimensions, one of them for the discharge of the fluid metal, and the other for the scoriæ. The ore is introduced at the roof of the furnace through a hollow shaped vessel.

The ores of lead, like those of most other metals, are combined with various kinds of earthy matter, which require them to be pulverized before they undergo the smelting process. The pounding is sometimes performed by hammers, but usually by a stamping mill, or by rollers. When thus reduced, the heavy metallic matter is separated from the lighter earthy matter by washing. The common mode of effecting this is to put the powdered metal into a riddle or sieve, immersed in a large tub of water, wherein it is agitated by a movement that washes away the small particles through the sieve, and ejects the lighter portion of the matter over the sides of the sieve; while the metallic portion, from its specific gravity, is less disturbed, and is collected at the bottom of the sieve. Some improved apparatus for this purpose was patented by Mr. Harsleben, in 1827, the description of which will be found under the article MINING. In some establishments in this country, and very generally abroad, the ores are washed upon inclined tables, which are shook by machinery, whilst water is made to flow over them to separate the metallic from the less ponderous matter; which apparatus is also described under the article MINING, as it is equally applicable to other ores as to the ore of lead.

An improvement in the furnaces for smelting lead ores was patented by Mr. Joseph Wass, of Ashover, Derbyshire, the main object of which was to obviate the injurious effects upon animal and vegetable life within the range of the metallic vapours emanating from furnaces of the usual construction. But in addition to this important desideratum, there results from the adoption of this improved arrangement a considerable profit, which arises from the product obtained by the condensation of those volatile and deleterious substances that are usually allowed to mix with the atmosphere. In the specification which is before us, the patentee states,—"By the employment of this improved apparatus, smelting and calcining furnaces are divested of their pernicious effects, and such works may in future be erected in any convenient situation, either near to dwelling-houses, or by the side of public roads, or on the banks of navigable rivers or canals; and thus, in many cases, produce a very great economy in the expense of carriage. The saving effected by this apparatus in preserving a quantity of valuable matter, which would otherwise, as heretofore,

escape, to the injury of the neighbourhood, would of itself amount in on where four furnaces are employed (as described in the plan) to a sum of the entire cost of the improved apparatus; that is, the upper part of the with its roof, cap, vane, shutter, and appendages" which we shall next p to describe.

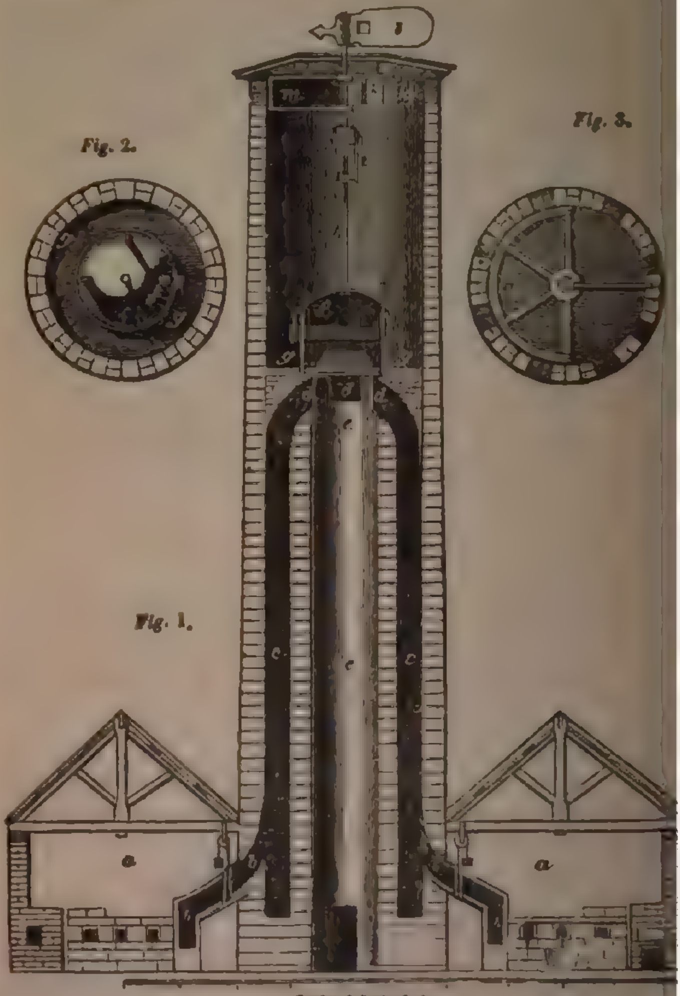


Fig. 2. *Fig. 3.* *Fig. 1.*

Scale of forty feet.

Fig. 1, in the preceding engraving, represents a vertical section of and capacious tower, placed in the centre of four smelting furnac receiving, by distinct flues, the smoke and vapour from each of them drawing being a *central* section, but two of the furnaces are brought int which are marked *a a*, their flues *b b* opening into separate chimneys c c tower, which they ascend for twenty or more feet; then, by lateral pass *d d d*, they respectively enter the central shaft *e e*; here the vapours

in contact with a powerful ascending current of cold air, and are likewise checked in their upward progress by striking against a dome or cap of iron *f*, which is suspended over the throat of the central shaft *e*. The ascending vapours thus intercepted and acted upon are, for the most part, immediately condensed, and the metallic particles are precipitated upon a floor *g*, called the *lodge floor*. A plan of this floor, and the cap *f*, are given in a separate figure (2), which is a transverse horizontal section of the tower just above the cap: another advantage resulting from this arrangement consists in the heat produced in the furnaces below, where it is found that the carbonaceous matter is more completely consumed than by the former disposition of things; such portion of the heavy particles that do not fall upon the lodge floor are precipitated to the bottom of the central shaft. The cap *f* is suspended by a vertical rod *h*, which is connected to a transverse beam by means of a sort of stirrup-iron *i*, through which the upper extremity of the rod is screwed, and by the turning of a nut upon this screw the height of the cap above the throat of the central shaft is regulated. The cap is steadied in its movements and preserved in its position by several upright bars passing through it, two of which are brought into view; these are perforated with holes, through which keys or bars are put to lock the cap securely in its place. The lower part of the cap or dome is circumscribed by a broad hoop; by the action of regulating screws, this hoop is shifted up or down over the periphery of the cap, and the passage for the vapours is thus more readily adjusted at pleasure. The more volatile portion of the vapours pass from under the dome, and ascend to the top of the tower, which, being covered with a roof nearly flat, the heaviest particles are thrown back, and fall condensed also upon the lodge floor, while the lightest and most pernicious escape into the atmosphere at the lateral openings *k k*. There are a regular series of vent holes all round this part of the tower, one half of which (those that happen to be windward) are always closed by a shutter *m*. The lower extremity of the shaft, upon which the vane *l* is fixed, turns in a bearing upon the cross beam; and the arms of the circular shutter being also attached to this shaft, when the wind turns this vane the shutter is, consequently, in like manner turned against it.

Fig. 3 is a transverse section of the tower immediately under the roof, by which the circular frame of the shutter is shown, as closing one half of the apertures, or those to windward of it. When the deposition from the condensed vapour has become considerable, it is removed from the lodge floor at a time when the smelting furnaces are not at work; this is done by a man ascending a narrow circular staircase, constructed in the masonry of the tower, up to the lodge floor, where he throws down the accumulated deposition with a shovel to the bottom of the shaft; from thence it is barrowed out, and carried to a roasting furnace. When any one of the furnaces is not at work, communication with the tower is to be cut off by means of a damper, as those shown at *o o*. In the drawings attached to the specification, a general plan of a smelting work is delineated. The area is inclosed by a quadrangular wall, with a smelting furnace on each side, the chimneys of which are conducted into the central tower. The corners of the quadrangle are occupied by the other buildings required in such establishments. The spaces between the angles of the several flues, the patentee states, may be conveniently occupied by small furnaces for tests and experimental purposes. Another improvement of the patentee deserves mentioning: he directs that the tapping sides of the contiguous furnaces to be made "opposite" to each other; by which is meant that they may both face the area which lies between them, in order that the fluid metal from the pipe of each surface may be run into pigs, or conveyed into one receiver, and thence into moulds, so as to be formed into thick sheets, ready for milling or rolling, by which arrangement of the furnaces it is considered an important saving of labour and expense will be effected, and the waste by remelting the lead avoided. In the process of smelting, the ore is spread upon the concave hearth, so that the flame may act upon it, and release the sulphur. When the sulphur has escaped, the lead combines with the oxygen, and the oxide of lead thus formed combines with and reduces the earthy matter to a liquid, which

floats upon the surface of the metal, and, for the remainder of the operation, protects it from the action of the oxygen. The temperature of the furnace is now considerably raised, to separate as quickly as possible the lead from the liquid scoria; after which a considerable portion of the scoria is tapped off, leaving only so much behind as is necessary to protect the metal from the action of the oxygen. The fire is now slackened, and a quantity of slack or refuse pit-coal thrown into the furnace, which serves to diminish the heat, and to concrete the melted scoria, which effect is promoted by the addition of powdered lime; the scoria thus consolidated is broken into pieces with a rake, and thrust to the opposite side of the furnace, where it is taken through the apertures already mentioned. The lead is now tapped in a manner similar to that described in the manufacture of iron, and allowed to run into a capacious iron pan, whence it is ladled into moulds to cast it into pigs. When the ores abound with blend, or black-jack, or with the sulphate of iron, fluate of lime is added as a flux. The scoria last mentioned contains a portion of lead, besides that which is in the state of oxide; it is therefore exposed to the heat of another furnace, being a species of blast furnace, and called a slag-hearth, which fuses the scoria and causes the metal to penetrate through it and fall into a cavity, where it is protected from the agency of the blast, and from whence it is taken and cast into pigs. All lead ores contain some portion of silver, which is extracted when it is in sufficient quantity to afford a recompense for the operation; the method adopted in France is very simple and efficacious, and is thus described in *Rees's Cyclopædia*:—"A shallow vessel, or cupel, is filled with prepared fern-ashes, well rammed down, and a concavity cut out for the reception of the lead, with an opening on one side for the mouth of the bellows, through which the air is forcibly driven during the process. The French smelters cover the surface of the ashes with hay, and arrange symmetrically the pieces of lead upon it; when the fire is lighted, and the lead is in a state of fusion from the reverberation of the flame, the blast from the bellows is made to play forcibly on the surface, and, in a short time, a crust of yellow oxide of lead or litharge is formed, and driven to the side of the cupel opposite to the mouth of the bellows, where a shallow side or aperture is made for it to pass over; another crust of litharge is formed, and driven off. The operation continues about forty hours, when the complete separation of the lead is indicated by a brilliant lustre on the convex surface of the melted mass in the cupel, which is occasioned by the removal of the last crust of litharge that covered the silver. The French introduce water through a tube into the cupel to cool the silver rapidly and prevent its spirting out, which it does when the refrigeration is gradual, owing, probably, to its tendency to crystallize. In England the silver is left to cool in the cupel, and some inconvenience is caused by the spirting, which might be avoided by the former mode. The silver thus extracted is not sufficiently pure; it is again refined in a reverberatory furnace, being placed in a cupel, lined with bone ashes, and exposed to greater heat; the lead, which has escaped oxydation by the first process, is converted into litharge and absorbed by the ashes of the cupel. The last portions of litharge in the first process are again refined for silver, of which it contains a part which was driven off with it. The litharge is converted into lead again, by heating it with charcoal; part is sometimes sold for pigment, or converted into red-lead. The loss of lead by this process differs considerably according to the quality of the lead. The litharge commonly obtained from three tons of lead amounts to fifty eight hundred weight; but when it is again reduced to a metallic state, it seldom contains more than fifty-two hundred weight of lead, the loss on three tons being eight hundred weight. The Dutch are said to extract the silver from the same quantity of lead with only the loss of six hundred weight."—See SEPARATION.

Sheet Lead.—There are two distinct kinds of sheet lead, cast, and milled or rolled. The first-mentioned is the original kind, and as it is preferred we shall first describe it as usually practised by the plumbers. A large cast-iron cauldron is built over a furnace, enclosed in solid masonry, at one end of the casting-shop, and near to the mould or casting-table. This table is generally

a parallelogram, about six feet wide, and twenty feet long, sub-
of wood, and bound together at the corners and other parts
face of the table is surrounded by a raised border about three
and five inches in depth; the legs and framing are of course
ly jointed, to prevent any yielding or trembling during the cast-
of the table is of boards, laid very even, and this is covered by a
sand laid very smooth and even; at the end of the table,
cauldron in which the lead is melted, is adapted a box, equal in
width of the table; at the bottom of the box is a long horizontal
which the metal flows out uniformly over the breadth of the table;
nted upon rollers, which run on the rim of the table as a rail-
t in motion by a rope and pulley. When the metal in the
ficiently heated to retain its fluidity throughout the spreading of
requisite quantity of it is ladled into the casting-box, and the
its surface by means of a perforated scummer. As soon as the
ed its contents upon the table, a man levels the surface with a
takes off the impurities also, before it cools; as soon as it has
are taken off in a straight line, and when sufficiently cool it is
removed away to make room and prepare for the succeeding
h are conducted in a similar way.
fferent from the foregoing is practised in some places. Instead
x travelling over an horizontal surface, the table is a little
n iron vessel at the upper end of the table next to the cauldron
o pour out the fluid which flows to the other end, during which
rkman levels the surface with a striker or straight edge, which
to a uniform thickness. Cast sheet-lead, made by these pro-
possess that very uniform thickness, nor that smoothness of
distinguishes milled-lead, or such as has been laminated between
rollers, actuated by a steam engine or other suitable prime
method by which this is done on the large scale is as follows:—
pable of melting ten or more tons of metal at a time, is substan-
over a common furnace; when the lead is at that temperature
lting point, which will prevent its congelation before it has flowed
part of the mould, the vessel is tapped by the pulling out of a
is attached to a bent extremity of a lever of the first class, the
hich is loaded with a weight, that acts as a compressing force to
in the tapping hole; a rope attached to the end of the loaded
er, and passing over a pulley, being pulled by a workman, the
y easily withdrawn; and upon the workman letting go the rope,
n the lever forces the plug into the hole again. (Owing to the
superincumbent portion of the metal in the cauldron above the
the lead is spirted with considerable force around the plug at the
entering or leaving the tapping-hole, which renders it dangerous
nding within the distance of a few yards; and as this dangerous
sily be prevented, we wonder that it is not done; such as apply-
reen to the tapping-hole, or the plug, and making the plug, as a
drical, instead of conical.) The metal is discharged into a very
ast-iron pan, laid perfectly level, and capable of holding a plate
n inch and a half thick, and weighing about five tons; when
iron pan or mould is hooked at the corners to chains, in the
le-board, and by the assistance of a large jib extending over it,
crane, is raised from its seat and swung round upon a table upon
laminating rolls. On this table, the plate is now divided into
r narrow plates, the numbers and dimensions of these depend-
ize and weight of the sheets to be made from them. The division
effected by very rude means; one man, holding an ash-rod,
chisel at the end of it to the chalk division line scribed on the
other workman, with a sort of sledge-hammer, made of a great lump
nd of a long handle, swings it round vigorously, and gives the chisel
umps as to send it through the thick plate of lead at each blow.

The laminating rollers are cast-iron cylinders, usually about eighteen inches in diameter, and about six feet long, turned and ground to a very true and smooth surface; the lower roller turns in fixed bearings, but the upper in adjustable bearings, which are acted upon by screws for regulating the distance between the rollers. The power is communicated to the lower roller through the medium of a reversing motion, which causes the rollers to change the directions of their respective rotations, according as the sheet of lead may be on one side or the other of them; on either of which it is supported upon a species of table, from twenty to thirty feet long, the surfaces of which are composed of a series of wooden bearing rollers. The plate of lead being introduced between the cylinders, is griped by them, and forced through by their revolution; the plate is thus extended by a reduction of its thickness, and is received upon the bearing rollers on the surface of the table; the workmen on each side of the machine now give the regulating screws a turn, by which the laminating rollers are brought nearer together; then the motion of these rollers is reversed, and the sheet of lead traverses back through them to the opposite side, where it is received on the bearing rollers of that table, considerably extended; the rollers are again adjusted nearer together, and the motion of them is again reversed for the next rolling through; the operation being thus repeated until the plate is brought to the required thickness. When this is done, the rough edges are cut off to a straight line, and the sheet rolled up off the table on to a truck adapted to the work, and wheeled away. Whilst this is being completed, another plate of lead is passing through the laminating rollers; and whilst all the plates of lead divided from the great cast-plate before-mentioned are being laminated in the manner of the first described, the casting department of the establishment is engaged in preparing to cast, or in casting another great plate, which is subsequently divided and placed in readiness for the continuation of the laminating operation.

The very thin sheet-lead, with which the tea-chests from China are lined, is made, according to common report, in the following manner:—A man sits upon a floor with a large flat stone before him, and another movable one at his side on a stand; his fellow-workman stands beside him with a vessel full of melted lead, and having poured out a certain quantity on the large flat stone upon the floor, the other immediately lifts the movable stone, and dashing it on the fluid lead, presses it out into a flat and very thin plate; the stone and lead are then quickly removed, and the operation renewed, which is repeated in quick succession. The rough edges are afterwards cut off, and the sheets soldered together for use.

The Tinning of Sheet-Lead may be effected in two ways. *First*, place the sheet of lead upon a hot stove, until it acquires sufficient heat to keep melted tin poured upon it in a fluid state; then throw a little powdered resin over the sheet, and when it has melted, with a greasy rag rub the tin and resin over the sheet of lead until it is completely covered with the tin; after which, wipe off the superfluous matter. *Secondly*, the tin in the cold state, and in small quantities at a time, may be laid on the plate of lead, carefully heated sufficiently to fuse the tin, (but not more so,) and by the help of resin and similar manipulation to the first-mentioned plan, the lead may be perfectly coated.

Lead Pipe.—The next article of importance in the lead manufacture is pipe or tubing. There have been various modes of producing it: the original mode, from some specimens of very old pipe that we have seen, appears to have been the wrapping of a strip of sheet lead, with parallel sides, round a cylinder so as to make their edges meet, and then unite them with solder. The specimens alluded to present phenomena worthy of notice in this place: the lead was full of holes, and was corroded more or less in every part, except at the seam, which the solder had entirely protected; and the solder itself was as sound and perfect as when it first left the plumber's hands.

Another mode of making lead-pipe, which probably succeeded the foregoing, and is still practised by some plumbers, is the following:—An iron mould is provided, which is divided into halves, and forms, when put together, a hollow cylinder of the external diameter of the extended pipe; in this cylinder is p

rod or cord, extending from the top to the bottom, and leaving all a space between it and the cylinder of the intended thickness of the pipe. lead is poured in at a spout, formed by two corresponding notches cut in half of the mould, and a similar hole is made at another place for the of air. The mould is fastened down upon a bench, upon which, at one and in a line with its centre, is a rack moved with toothed wheels and ns. When the pipe is cast, a hook at the end of the rack is put into an the end of the iron core, which, by the action of cog-wheels and pinions, awn so far out that about two inches of it only remain in the end of the , the two halves of the mould, which fasten together by wedges or screws, are separated from the pipes, and are fastened upon the iron core, and the inches of lead-pipe attached to it. Melted lead is now again poured into mould, when the fluid lead unites with the end of the first piece of pipe; this process being continued, pipe of any required length may be made.

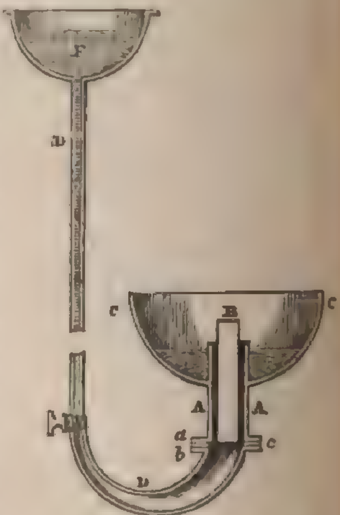
third method, which was patented in 1790 by the great iron master, John kinson, consists in casting a very thick pipe in a mould, having a cylindrical of the same diameter as the intended pipe, and then inserting a polished mandril up the bore of the pipe, in which it is to be successively passed ugh a series of round grooves, precisely in the same manner as has been cribed under our article IRON, for making round bars. Every time that the e is passed through, the lead is compressed upon the mandril, consequently uced in its thickness, but extended in length, while the internal bore remains altered, except the improvement it derives from condensation of the metal inst the polished mandril.

A fourth method is mentioned in Mr. Wilkinson's specification, which, since the piration of the patent, has been, and is still practised with unimportant variations by all the considerable manufacturers of lead pipe: it consists as follows:— ry thick short pieces of pipe are cast, similar to those described in the preceding method; the external diameter may be two or three times that of the intended pipes, but the internal the same. The central hole for the mandril of latter does not extend the entire length of the pipe, but terminates with a much smaller hole at the extremity; a stop to the triblet is thus formed, which employed in the succeeding operation, which is that of drawing the lead pipe rough a hole precisely in the same manner as wire is drawn. The triblet or lished mandril is of somewhat greater length than the pipe intended to be nufactured by it, which is commonly from nine to twelve feet. Through the all hole of the cast-lead pipe is then passed a screw, which is screwed into end of the triblet, that abuts against the shoulder; and it is by this connexion with the triblet that the lead pipe is drawn successively through a series separate steel plates, each having a different sized hole, and which are successively deposited in solid recesses made in very firm bearings, and are exchanged for smaller after the pipe has passed through the larger one. The e draw bench on which the operation is conducted is usually about 30 in length; it is provided with a strong endless hitch-chain passing around r wheels at the ends of the bench, to one of which the power is communicated. The screw fastened to the end of the triblet passes through the drawand is then secured by a hook and eye, or other fastening, to the endless n, the machinery being then thrown into gear by the ordinary means, the n drags the lead through the steel hole, by which its dimensions are reduced, d its length increased. The motion of the chain is now reversed, either by inery connected with the power, or the chain is thrown out of gear with power, when the chain can usually be drawn back by hand, and the draw changed; when, by throwing into gear again, the work is renewed, d so continued until reduced to the required dimensions; a small piece of end of the pipe being cut off it is finished.

A very ingenious mode of *casting* lead pipe of any length by a continuous cess was invented by Mr. John Hague, and patented by him in 1822, which e ll not omit noticing in this place. A rectangular cast-iron vessel, taining the lead, was placed over a suitable furnace, to melt and preserve it a fluid state; through this vessel, in a horizontal direction, was passed a

very stout cast-iron cylinder, each end of which came to the outside of the vessel, at a short distance from which they were each connected to a small reservoir of water to keep them cool. A hole about half an inch in diameter was made in the upper side of the cylinder through which the latter was charged with the fluid metal, and the hole was then stopped by a plug screwed down from above. The internal diameter of this cylinder was about six inches, and throughout its length of two feet its surface was cut into a screw thread; and into this a solid screw plunger worked from one extremity, which by its revolution gradually forced the metallic fluid through a mould and core fixed at the end, where the pipe was constantly drawn off as it solidified (by the cooling influence of one of the before-mentioned reservoirs of water) on to a drum, loaded with a weight upon its axis, which caused the drum to turn round with just sufficient force to wind the pipe upon it as it was formed.

A different method of casting lead pipe continuously, has lately been patented in the United States of America by a Mr. Titus, which is thus described in the *Franklin Journal*, with reference to the subjoined cut, which represents a vertical section of the essential parts of the apparatus. A A is a hollow cylinder of metal, bored out, so that its inner diameter shall be equal to that of the pipes intended to be cast. Its length, for a pipe of 1¼ inch may be about 8 inches. It has a flanch *a a* at its lower end. This tube gives the form to the outside of the tube to be cast. B is a plug or core, adapted to the inside of the pipe, and made of iron or other suitable metal; it must be perfectly smooth and slightly tapering, being smallest at top. It has a flanch *b b* adapted to the flanch *a a*; this flanch is perforated with a number of holes, to allow the fluid metal to pass up into the mould. C C is a basin to contain water standing up to the dotted line *f f*. D D is a tube by which the melted metal is to be conveyed from the melting-pot F into the mould. A stop-cock regulates the flow of the metal. The tube D D is furnished with a flanch *c*, by which it is connected with the mould. The melting-pot may be placed so high up, that the pressure of the melted metal will be sufficient to force the pipe from the mould, with a regular motion, as it is cooled by the water; this force being regulated by the quantity admitted by the stop-cock. The pipe D D must descend through a flue kept sufficiently heated to keep the lead in a fluid state, and heat must also be applied at its junction with the mould. Instead of elevating the melting-pot, an arrangement may be made for making a mechanical pressure upon the surface of the lead, and thus to produce the same effect. The pipe, as it is forced off, may be received upon a reel or drum placed above the mould. Under proper modifications, which experience alone must suggest, the principle described in this and Mr. Hague's process may be advantageously applied to the accomplishment of the object proposed.



In the application of lead pipes as conduits for beer, wine, vinegar, and other acid liquors, serious objections have been made by many scientific writers, on the ground that poisonous solutions of the metal are thereby formed. The editor of *The Chemist*, observes in Vol. I. p. 227, that "wherever water kept in leaden vessels is allowed to come into contact with air, the lead becomes oxydated; and though the water has no direct action on the lead itself, it has

...ide; it dissolves a portion of it, and becomes poisonous;" and Mr. S. ...author of several pharmaceutical works, says in his *Operative Chemist*, ...the use of lead for cisterns, or even pipes, ought to be discontinued." ...Warner informs us, that soon after the introduction of the convenient ...apparatus employed by publicans, called beer engines, it was found ...portion of the beer which filled the *leaden* conducting pipes from the ...e cellar, and had remained therein during the night, or for several ...ing the day, had obtained a flat, bad taste, and was highly deleterious, ...the lead it had dissolved during that time. This alarming discovery ...sed the abandonment of beer engines. Attempts were made to sub-...es made of other metals or alloys, but without success; for leaden ...continue to be used, but with the necessary precaution on the part of ...an, or other vendor, to draw off and *waste* the beer contained in the ...unting to several pints or quarts every morning; and this precaution ...es resorted to during the day.

...te the disadvantages attending the use of lead pipes, the skill and ...of many ingenious men have been exercised. The first, we believe, ...rs. John and George Alderson, who contrived to put an interior case ...ead pipe; but they did not succeed in making a firm junction between ...ncentric pipes. Alderson's method was, however, improved upon by ...Dobbs, of Birmingham, who took out a patent in December 1820, for ..., which is entitled a "new mode of uniting together or plating tin ..." The patent includes the tinning or plating of ingots and sheets of ...des that of pipes; the process with respect to the latter is thus ...in the specification:—"First, in order to unite tin with lead-pipes, or ...ver, or plate them with tin, I take the pipe hot from the mould in ...as been cast, and lay it horizontally upon a bed of hurds, rags, or ...h has been previously prepared or impregnated with turpentine, or ...ous substance, a small quantity of melted tin having been also pre-... on the said bed of hurds, rags, or tow, prepared or impregnated as ...with turpentine, or other resinous material, until the surface of the ...mpletely tinned. I then attach to the end of a rod or wire a bunch ...rags, or tow, prepared or impregnated as aforesaid with turpentine, ...uce it within the pipe, together with a little melted tin, and work the ...and down, in manner of the piston of a pump, until the inside is .... I then place or fix the pipe in a larger pair of moulds, so as to ...cancy also between the pipe and the mould; and I also introduce ...mall core into the centre of the lead pipe, leaving a vacancy also ...e pipe and the core. I then take melted tin out of a furnace, and with ...our the tin down the two vacancies before-mentioned, by which means ...dies are perfectly and soundly united, and the lead pipe is united or ...h inside and outside with a thick coating of tin. In this state it is ... for drawing or rolling, whichever may be the most convenient. It ...ssary that the tin should be quite pure to be united to lead by this ...it may be alloyed with other metals. The moulds and cores I use ...e as those generally employed by lead-pipe makers, excepting that ...em made of copper or brass, instead of wrought and cast iron." Tin ...ch harder and less ductile metal than lead, considerable difficulty ...in drawing them together, so as to get them sound in every part; ...racks and flaws being discovered in the tin, which would not so ...d as the lead to the forcible extension they underwent. From this ...ce, and the greater rigidity of the tin, they could not be made to ...bending to which lead pipe is necessarily subjected by the plumber; ...not therefore successfully brought into use. About the same period ...ere drawn of pure tin, and rendered at a price lower than the tin ...could be afforded.

...ing, however, no other known metal which possesses the same ...exibility and durability as lead, it was still deemed a most important ...to give a perfect coating of tin or other innocuous metal to lead ...ut impairing the flexile or other valuable properties of the latter; and

this we are happy to add has been supplied by a new process, very recently patented by Mr. John Warner, jun.; the specification of which describes that process to be as follows:—A bath of melted tin is prepared in a vessel of a suitable form and size, which may vary according to the size of the pipe to be tinned, (or the size and shape of any other leaden article to be tinned.) The heat of the bath is to be so regulated that the metal shall continue in a fused state, but not at a higher temperature than is necessary for that purpose, lest the lead when immersed should be melted thereby; the heat may be ascertained by the use of a thermometer, or a pyrometer; likewise by testing it by such alloys of tin and lead as will melt at certain given temperatures, between the melting point of tin (or such alloy of tin as may be used as a substitute for the pure metal,) and that of lead, *when placed under the influence of a bath of melted tin.* This, the reader will observe, is a very nice point, and can only be practised by great skill and attention on the part of the workmen; for although tin melts at about 440° and lead at 612° of Fahrenheit's thermometer, yet, when they come together, an alloy is produced at the immediate points or surfaces in contact, whose fusibility is much lower than even that of tin; so that when, by mismanagement, the heat is raised a few degrees too high, a quantity of the lead in the form of an alloy runs off the pipe into the bath; and if, on the contrary, the heat be suffered to fall a few degrees too low, the tin is not sufficiently fluid, and deposits itself upon the lead in a thick and uneven coat. When the pipes are to be tinned all over, the external surfaces are sprinkled with powdered resin, and the same material is blown up the pipes so as to cover their internal surfaces with it; a mixture of oil and resin boiled together is, however, preferred to the resin alone. The said mixture is to be spread over the surfaces of the lead pipes by any convenient means, and when they have been so prepared, they are to be passed through, or immersed in the bath of melted tin, which should be covered with fat, oil, or resin, to prevent the oxidation of the fluid metal, and to aid in the tinning But when the pipes are to be tinned on one side only, or partially, those parts which are *not* to be tinned are covered with a mixture of lamp-black and size, or with any other matter that will prevent the action of the tin upon the lead; and those parts that *are* to be tinned are to receive the powdered resin, or the mixture of oil and resin, as before mentioned. The pipes thus prepared are then to be passed through, or immersed in the bath of liquid tin, by which process they will be tinned only in the parts required. When the pieces of pipe to be tinned are of a small size they may be easily managed by hand; but when they are of considerable weight or length, a rope and pulley is resorted to, to draw them through the bath of melted tin: the form of the bath is that of a segment of a cylinder having two flat sides; the chord of the segment being the top or open part of the vessel, where it forms a parallelogram of about six inches wide and two feet long. This form, it will be perceived, accommodates the bended form of the pipes, to dip in at one end of the vessel, and curving round the bottom, to come out at the other end; the tin thus flowing in at one extremity of the pipe, and running out at the other. This process, as we have had occasion to notice, gives a perfect coating of tin, and fills up any minute fissures or holes that there may be in the pipe, besides enabling the manufacturer to give the pipe any required thickness of coating, by drawing it any number of times through the bath. But an extremely minute quantity of tin covers the surface effectually, and by not impairing the flexibility of lead, adapts it to every purpose to which both lead pipes and tin pipes are used, and at the most trifling cost above that of lead.

Strength of Leaden Pipes.—Some experiments upon this important subject were made by Mr. Jardine, of the Water Company in Edinburgh. The method of proving was to close one end of a piece of pipe, and then inject water into it by means of a forcing pump attached to the other end, the force or pressure being measured by a gauge belonging to the pump. When the water from the injecting pump begins to press out the pipe, little or no alteration is observed in it for some time. As the operation proceeds, however, the pipe gradually swells throughout its whole length, until, at last, a small protuberance is observed rising

in some weak part, which increases until the substance of the pipe, becoming thinner and thinner, is at last rent asunder. In the first experiment, the pipe was of one and a half inch bore, and the metal, which was remarkably soft and ductile, was one-fifth of an inch in thickness. This sustained a power equivalent to that of a column of water one thousand feet high, equal to thirty atmospheres, or 420 lbs. per square inch of internal surface, without alteration; but with a pressure equal to twelve thousand feet of water it began to swell, and with fourteen thousand feet, or six hundred pounds on the square inch, it burst. When measured after the experiment it was found to have swelled until of a diameter of 1¾ inch. The edges of the fracture were not ragged, but smooth like a knife. In a second experiment, the pipe was two inches in diameter, and one-fifth of an inch in thickness. It sustained a pressure equal to that of a column of water eight hundred feet high, with hardly any swelling, but with one thousand feet it burst; the fracture in this was not so fine as in the former instance, the metal being much less ductile.

Red Lead and Litharge.—We have described, at page 52, the method of refining lead for obtaining the silver which it usually contains, by which process there results an oxide of lead, called *litharge*. The use of this substance for making oil and oil paints dry sooner is well known; it remains to be observed in this place, that it is the material from which red lead is made. The litharge is put into pots, and exposed to the action of flame in a reverberatory furnace for forty-eight hours, during which time it is frequently stirred; hence it acquires the orange-red colour, termed minium, or red lead. There are other modes of obtaining red lead. In Germany and some other places, metallic lead is calcined on the hearth of a cupola furnace, and constantly stirred for eight hours, then left in the furnace for sixteen hours more, stirring only at intervals. The massicot thus produced is then ground in a mill, washed, dried, and put into earthen pots, so as only to make them about a quarter full, in which they are exposed to the action of flame, enveloping them in a furnace for forty-eight hours, by which time, the colour being fully developed, the pots are taken out, and their contents passed through sieves to separate any foreign or gross matter. A hundred pounds of metallic lead thus produces about a hundred and ten pounds of red lead; the increase arising from the absorption of oxygen. The specific gravity of red lead is 8.94.

Sugar of Lead is obtained by dissolving the metal in acetic acid, concentrating the solution, and crystallizing.

Turner's Patent Yellow, now almost entirely disused, may be obtained by pouring upon litharge, one-third of its weight of muriatic acid, and, after letting it stand for twenty-four hours, melting the whitened litharge, by which it becomes yellow. Goulard's extract is made by boiling litharge in vinegar.

Chromate Yellow.—This beautiful colour, which has superseded the use of the last mentioned pigment, is obtained by precipitating a solution of lead in acetic acid, by the addition of a solution of the chromate of potash.

Lead is rapidly dissolved by the nitric acid. Wooden sticks, impregnated with a nitric solution, made by dissolving the cuttings of lead in weak nitric acid, have been recommended by Proust, as a substitute for port-fires, in discharging artillery. Most of the acids attack lead. The sulphuric does not unless it be concentrated and boiling. When lead is alloyed with an equal weight of tin, it ceases to be acted upon by vinegar. Oils dissolve oxide of lead and become thick and consistent, in which state they are used as the basis of cements for water works, the vehicle for paints, and various other purposes. Sulphur dissolves lead in the dry way, and produces a brilliant and brittle compound, which is much more fusible than lead itself. Lead unites with most of the metals. Gold and silver are dissolved by it at a light red heat. Platina forms a brittle compound with lead; mercury amalgamates with it, but the lead is again separable from it by mere agitation, in the form of an impalpable black powder. Copper and lead do not unite without a strong heat; but the union of these metals is extremely slight, for at no greater heat than the melting point of lead it runs from the copper. Iron does not unite with lead in the metallic state. Tin unites very readily with lead, as already shown

in the process of tinning lead pipes and sheets. The compound of these metals being very fusible, it is used as a solder either separately or both together. The mixture is made in various proportions: the *best* solder is said to be two parts tin and one part lead; and the common solder, two parts lead and one part tin. Bismuth combines readily with lead, and affords a metal of a fine close grain, but very brittle. A mixture of eight parts bismuth, five lead, and three tin, melt at a heat below that of boiling water. Antimony forms a brittle compound with lead: see the article ALLOY. Nickel, cobalt, manganese, and zinc, do not unite with lead by fusion

LEATHER. The skins of animals, combined in a variety of ways with astringent and other matters, to adapt them to numerous purposes of utility. The art of preparing leather is very ancient, and is practised in almost every country of the world by nearly similar processes. The objects obtained by this art are, the prevention of their destruction by putrefaction; the rendering them strong, tough, durable, and impervious to moisture; and in giving them a bright and beautiful appearance by dying and polishing; according as these qualities may be required. The preliminary operation in making all kinds of leather, is the separation of the fleshy and other foreign matters adhering to the skin, the animal juices retained in its pores, and also the cuticle with its hairy covering, excepting in those instances wherein the wool is required to be left on, as in the case of sheep-skin rugs. The skins, after being duly purified, and their texture opened so as to adapt them to imbibe other matters in solution, are made into leather by two different processes, one called *tanning*, and the other *tawing*, and both these processes are sometimes combined in sheep, goat, and deer skins, by tawing first and tanning afterwards, in a slight manner; and a large proportion of the tanned hides of the horse, ox, and other large animals, undergo an operation called currying, to render it flexible, and resist water. There are many trifling variations in the processes adopted by different tanners and leather-dressers with respect to the same kind of skins, and each kind is treated differently in some respect, either in consequence of its natural peculiarities, or the application to which it is designed when finished. Our descriptions will, therefore, apply to the general mode of proceeding in the principal sorts of leather.

The thin skins of cows, calves, and others of a similar texture, are soaked for two or three days in a pit of water to free them from dirt, blood, and other matters that may slightly adhere to them. They are then taken out, and laid upon a horse or beam, (which is usually a semi-cylindrical piece of timber, or the rib of a whale,) whereon they are scraped and pared, to free them from any adhering flesh, fat, &c. The hides are next immersed in a pit containing milk of lime, wherein they are frequently stirred, and are allowed to remain until the cuticle of the skin is so far destroyed as to be easily rubbed or pared off along with the hair to which it is connected. When this is found to be the case, they are taken out, stretched upon the beam, and with a large two-handled blunt-edged knife the workman scrapes off the hair. In lieu of this liming process, in some places, the hides were formerly piled wet one upon another, and covered over with spent bark, (or otherwise kept warm in what was called a smoke-house,) until the cuticle and the hair would readily come off. The absorption of lime in the before-mentioned process makes the skins hard and thick; to render them supple, and prepare them for receiving the tan liquor, they are thrown into a pit called the poke, or mastering-pit, which contains a quantity of putrescent dung diffused in water: the dung of dogs, pigeons, or sea-fowl, is preferred for this purpose, that from cows and horses not being sufficiently powerful. During the process they are frequently well stirred, and sometimes taken out of the pit, piled up, and put in again. When the skins have become perfectly soft, they are taken out of the putrescent pit, and cleansed on the beam, when they are ready for tanning. The large thick hides of the ox or boar, intended for the toughest sole-leather, being not so liable to sudden injury as the thinner skins, are frequently cleared of their hair and other matter without resorting to the liming process. They are allowed to ferment, piled up in a warm place, and the putrefactive process

is carried farther, that the cuticle and hair may be easily removed. When this has been done, they are immersed for several days in sour liquor, made from fermented barley, or rye meal; the acid is generated in the process, and seems to be the active agent in softening and opening the texture of the skin, assisted by the continuance of the fermentation, of which the skin partakes. This process, which always precedes that of tanning, is called raising, as it has the effect of considerably swelling the skin. Instead of the foregoing acid, some tanners use very dilute sulphuric acid, in the proportion of about four pounds to a hundred gallons of water.

The process of tanning is essentially the same in all skins. It consists merely in immersing the skin for a sufficient length of time in an infusion of oak bark, or other vegetable astringent, until it is completely saturated with it. Hence the art of preserving the hides of animals by this method is one of the most ancient and universal of all manufactures, no apparatus whatever being required to perform it, except a pit or hole for water, in which the tanning vegetable may be put, and the skin thrown in along with it. Almost equal simplicity is observed in the most improved methods of tanning, the art mainly consisting in judiciously regulating the strength of the tanning infusion, and in the manipulation of stirring the hides in such a manner, that all that are in a pit may be equally impregnated.

The substance used in this country is chiefly oak bark, which is ground into a coarse powder, and is thrown into pits with water, by which an infusion of the tan, and other soluble parts, is made, which is technically called *oose*. The hides (previously prepared in one or other of the ways before mentioned,) are first put into small pits, with a very weak *ooze*, where they are allowed to macerate for some weeks, with frequently stirring, or handling, as it is termed. As the process of tanning proceeds, the strength of the different oozes is gradually increased, after which, the half-tanned hides, (if of the thick kind, intended for sole leather, and which require very complete tanning,) are put into larger pits, with alternate layers of ground bark, in substance, till the pit is filled, over which a heading of bark is also laid, and the interstices filled up with a weak ooze to the brim. The hides are by this arrangement supplied with a quantity of fresh tan in proportion as they absorb the tan, previously dissolved in the water. By this mode of tanning, the thickest leather takes fifteen months before it is thoroughly tanned throughout; which is ascertained by cutting a piece off the edge of the hide, when it should appear uniformly throughout its thickness of a nutmeg-brown colour, and any portion that is not tanned will exhibit a whitish or pale-coloured streak in the middle.

M. Seguin, a French chemist, investigated the process of tanning with great assiduity, and came to the conclusion that by condensing the tanning principle so as to accelerate its action, leather might be tanned in a less number of days than it usually takes of months. To effect this, his process is simple. He pours water upon the powdered tan, contained in an apparatus nearly similar to that made use of in saltpetre works. This water, by going through the tan, takes from it a portion of its tanning principle, and by successive filtrations dissolves every time an additional quantity of it, till at last the bark rather tends to deprive it of some than to give up more. Seguin succeeded in bringing these solutions to such a degree of strength that he could, according to his own statement, completely tan a calf-skin in twenty-four hours, and the strongest ox-hide in seven or eight days. These solutions containing a greater quantity of the tanning principle, impart (it is said) to the skin as much of it as it can absorb, so that it can then easily attain a complete saturation of the principle, and produce leather of a quality much superior to that of most countries famous for their leather.

When a patent for Seguin's method was taken out in this country, Mr. Nicholson stated, that from information acquired from the manufacturers, he found that they had previously been sufficiently acquainted with the powers of strong tanning infusions, and that it had even been proposed to employ them so as to abridge the process, but the leather thus produced was by no means equal

to that produced in the old way. The advantage of the slow and gr... cess appears to be, that the whole substance of the skin is penetrated a... changed; while in the more rapid method the external must be more ... and the texture probably more unequal. It appears also from Sir H... experiments, to combine with a larger quantity of the extractive m... tained in the astringent infusion; and hence, too, the advantage of th... sions in the weak liquors, as these contain more of this than the strong... It must be confessed, however, that for any thing theory can discover, ... mon process appears to be unnecessarily protracted, and some advanta... probably be derived from adopting some of the manipulations of Segu...

To accelerate the process of tanning, *warm* infusions of the tanni... instead of cold, have been employed, and we are informed with some ... success. With the same object in view, it has likewise been attempted ... leather by *forcing* the tanning liquor into the pores of the skin by m... pressure. The first of these attempts was made by Mr. Francis Gib... bury, of Walsall, in Staffordshire, who took out a patent for his proces... which he thus describes in his specification:—"My invention consi... introduction of the tan liquor, by means of mechanical force, into the ... substance of the skin or hide, which I effect in the following mann... skin or hide being cleansed, and otherwise prepared in the usual wa... action of the tan liquor, is to be carefully examined, and any holes th... found are to be sewed, or otherwise secured, by means which are we... so as to prevent the liquor from running through; after which it is in ... state to be exposed to the action of the tan liquor, in conjunction wi... nical pressure, which I effect in the following manner. I provide thr... of similar shapes, made of wood, copper, or any other suitable materi... mention that the use of iron for this purpose, unless covered with a ... paint, should be avoided, as its effects would be to blacken the skin, ... and furnished at the sides with ears or loops, for the reception of sc... the object being, by means of the outer frames, to press two skins or h... on each side, against the middle frame, and through an aperture in th... frame to introduce the tan liquor under pressure into the space th... between the two hides, the effect of which will be to produce a continu... tion or percolation of the liquor; and in consequence of which, the ... process rapidly takes place. The middle frame differs from the others ... two pipes let into it at the top, and a cock let into it at the bottom. O... exterior frames being laid flat down, with its inner surface uppermost, ... hide, previously prepared as aforesaid, is laid or stretched over it; ... frame is then laid on, taking care that the edges of the skin or hide ... every where griped or nipped between the two frames; a second ski... prepared as aforesaid, is then to be laid on the middle frame; and ... other exterior frame is to be laid on, care being taken that the edg... second skin or hide shall be every where griped or nipped between th... frame and the last exterior frame. The frames and skins are then to b... by means of screw bolts, entering into screwed holes, in the ears or l... frames are then to be raised upright; one of the pipes is to be secured ... communicating with a cistern containing tan liquor; the other pipe is ... open for the escape of air, and the cock at the bottom is to be closed. ... of the pipe communicating with the cistern being opened, the liquor ... in the cistern will flow down, and will occupy the space between the ... or hides, driving out the air. When the liquor has risen into the pi... escape of the air, showing that the space is filled, its cock is to be clo... which the tan liquor between the skins or hides being subjected to h... pressure, by means of the communication with the cistern (and whi... produced, increased and varied by methods well known), will be force... the pores or substance of the skins or hides, and will appear in the fo... or small drops, on their outward surface. The time required for comp... tanning will vary according to the density of the skins or hides, the ... the tan liquor, the amount of the hydrostatic pressure, and other circ... When the skins or hides are found to be tanned, they are to be rem...

...mes, and their outer edges, as far as they were squeezed or nipped ... the frames, must be pared off; the skins or hides are then to be dried, ...pared for market in the usual manner. It is not my intention to claim, ...this patent, the exclusive use of the frames, screw bolts, pipes, or any ...of apparatus herein mentioned; or the use of any particular kind of tan ...or any mode or process of preparing and of finishing the skins or hides, ...except the application of the machines or engines herein described or ..., or any imitation of them, for the purpose of causing the tan liquor or ...to pass, by filtration, or percolation, through skins or hides. The appa... herein described for effecting this purpose is such as I have employed ...success, and consider, upon the whole, to be best; but particular local ...ns, or other circumstances, may render it expedient to change the ...of the frames, or their vertical positions, for some other; or to enclose ...the middle frames and either of the exterior ones, two or more skins ..., instead of the single one, as above mentioned. *Fig.* 1 is a front view, ...2 is a side view. The same letters of reference indicate the same parts ...figure; *a a* is one of the exterior frames; *b b* is the other exterior ...*c c* are two hides, secured between the exterior frames and the middle ...by means of the screw bolts; *d* is the cistern containing the tan liquor; ...pipe through which the tan liquor descends from the cistern into the ...cavity between the two hides, and which will vary in length according

1 2

...amount of hydrostatic pressure intended to be given; *f* is the exit pipe, ...which the air escapes when the liquor is running down through the ...; *g* is a cock for the purpose of discharging from between the skins."

...ly after Mr. Spilsbury enrolled his specification, another person took ...patent for a slight deviation in the apparatus, but on the same principle

as Mr. Spilsbury's. Neither of these gentlemen, however, according to our information, have as yet succeeded in bringing their plans into practical operation, owing, we understand, to the curious circumstance, that the pressure has a tendency to drive the gelatin out of the skin, and to convert it into a very hard and inflexible material, not at all applicable to the ordinary uses of leather.

In 1827, Messrs. Knowlys and Duesbury obtained a patent for improvements in tanning, having a similar object in view, and, as it appears to us, with an arrangement better calculated to succeed. The skins were to be suspended vertically in a large air-tight vat, which, as well as the skins, were to be completely exhausted of air, previous to saturating them with the tan liquor, which the skins will, in consequence, more readily imbibe. A large aperture, or man-hole, is made in the top of the vat, for a workman to descend and hang up the skins, which are stretched from side to side upon hooks, at a regular distance apart, and kept in vertical and parallel positions by leaden weights, at their lower edges. This being done, a *weak* infusion of tan is admitted, until it covers the hides; the workman then closes the man-hole by the cover, which is rendered air-tight by a proper packing upon its rebated edges; the air is next exhausted by the air-pump as far as may be deemed necessary; in this state the vessel is to remain for a day or two, when the air may be re-admitted by a stop-cock, and the liquor pumped out through a pipe at the bottom of the vessel. The hides are then to remain to drain, and in contact with the air for a few hours, after which a second infusion of tan, stronger than that first used, is let in to cover the hides, and the process repeated as often as may be found necessary to completely tan the hides, increasing the strength of the liquors at every successive operation.

Our transatlantic brethren are not behind us in attempts to improve the old system of tanning. In the Journal of the *Franklin Institute*, we find the following specification of an American patent, granted to Osmond Cagswell, in 1831, which seems to be well deserving of the attention of the British tanner:—"The improvement consists in applying a solution of oak or other bark to hides or skins, in such manner, as that when the glutinous particles of the hide have absorbed and become mixed with the tanning or astringent principle, the other part of the solution (viz. the water) may pass off, and leave the hide free to receive more of the solution, and so on till it is tanned. The object is to expedite the process of tanning, and, consequently, to diminish the amount of capital necessary to be employed in the business. The *apparatus*, and *mode of application*, is as follows: Make a frame of timber, of a square form; the width to be made as great as the width of the hides, parts of hides, or skins, that are to be tanned; the height and length to suit convenience. Near the bottom, or ground of said frame, a light floor is to be formed of the length and breadth of the frame; said floor to incline to one side, so as to carry off the liquor after it has passed through the hide; the sides and ends to be raised from two to four inches above the floor, by fastening strips of plank on the inside of the frame; this will appear like a box,—say four feet wide, two inches high on one side, and four on the other, and twenty feet long; (these boxes may be fixed one above another, about twelve inches apart, to the top of the frame;) said boxes to be filled with *sawdust*, or any other soft porous substance that will not prevent the solution from running through the hide, and, at the same time, absorb and carry it off after it has passed through. On this surface (of *sawdust*) the hides, sides, or skins, (after having been prepared in the usual mode for tanning, except that the flesh is to be taken off clean,) are to be smoothly spread out, and, in order to keep on them a sufficient quantity of the solution, make sacks of coarse cotton or other cloth, an inch or more in diameter; fill them with the same material that the boxes are filled with, and place them around under the edges of the hides, which will raise said edges equal to the diameter of the sacks. After this is done, pour on the hides as much of the solution as the hollow surface which they will then present will hold, and continue to fill them up as it runs off through the pores of the hide for the space of from three to fifteen days (the time in

proportion to the thickness of the hide or skin), in which time they will be tanned, except the extreme parts or edges, which cannot be brought so fully under the process as the other parts of the hides; and in order *perfectly* to tan them it is necessary to lay them in vats after the common mode, for three or four weeks."

In 1832 Mr. William Drake, of Bedminster, near Bristol, specified a patent "for an improvement in tanning hides and skins," the novelty of which consists in applying the tanning liquor on one side only of the skin, and causing it to ooze through the skin to the other side, whence the aqueous portion of the liquor is abstracted by *evaporation*; the results of which process are stated to be, that the skins are more thoroughly and uniformly tanned, and that the operation is completed with *cold* liquor in ten days instead of ten months. The specification states that the skins are to undergo the usual primary process of *liming*; they are then to be immersed and well *handled* in a vessel containing *backward* (a weak solution of tan) until thoroughly saturated, which removes the lime and prepares them for a stronger impregnation. Thus prepared, the skins (excepting such as are intended for butts and middlings) are to be rounded; then two of them are to be laid face to face, and be carefully sewn together with waxed thread at their edges, so as to form a kind of bag impervious at the junction, leaving a small opening at the shoulder for the insertion of the neck of a funnel shaped vessel; but the patentee observes, it would be better to sew between the skins a collar adapted to receive the end of the funnel. As bags so formed would bulge out when filled, they are to be confined between two gridiron-like frames of parallel bars, adapted to compress the bag in such a manner as to produce internally a vertical stratum of liquid of about an inch in thickness between the two skins; and as the skins are thickest towards their middles, this variation is compensated for by cutting away a portion of the vertical wooden bars from a straight into a hollow curved line. The skins are suspended by loops to the bags, which traverse the upper horizontal bars of the frames, and the two frames are duly drawn together by four screw bolts passing through the extremities of the top and bottom bars. The funnel being inserted into the aperture between the skins, it is charged with strong tan liquor sufficient to distend the bag, and leave a surplus quantity to supply the loss by evaporation after the moisture has penetrated to the outside of the bags; a small gutter at the bottom of and between the frames receives whatever liquors may drop from the skins, and conducts it into a vessel, by which it is returned whenever necessary into the funnel reservoir above. To prevent the compression of the vertical bars from forming permanent indentations and ridges in the skins, the patentee directs that the bags be occasionally shifted a little laterally.

To facilitate the evaporation, and consequently the absorption of fresh solutions of tan, the operations are recommended to be conducted in chambers artificially warmed, and the liquor which oozes through the skin, and is received into the gutters, is directed to be conducted into vessels acting the part of refrigeratories, in order that *cold* liquor may always be supplied to the skins; (but how this liquor is to be preserved cold in a warm chamber, the specification does not explain). When the skins are sufficiently tanned, a stitch or two of the sewing at the bottom of the bag is opened, and the liquor is received into, and carried off by, the gutter underneath.

The claim to invention in this patent consists in the mode of accelerating the penetration of the tanning liquor by exposing the outer sides of the skins to evaporation. The process seems to be well calculated to economize time, but there is one defect in the arrangement for which we would suggest a remedy. The skins being laid vertically, the pressure of the column of liquid will cause a much more rapid absorption of the tan in the lower than in the upper part of the skins; and if no injury be sustained by the lower, by continuing the process until the upper is fully saturated with tan, there is, at the least, a loss of time. It is also probable that the liquor is stronger at the bottom than at the top of the bag. From both these causes, therefore, we should not expect that the leather produced would be uniform in its quality. To obviate these defects, we recommend the patentee to suspend his frames midway upon revolving axes,

[illegible] a charging vessel with a stop-cock, or [illegible] answer the same purpose: the bags may then be reversed at pleasure, by swinging them round upon their axes into any desired position, and the lateral shifting between the bars will take place of itself. If there were only one charging vessel with a stop-cock to it, it would suffice; as by turning the frame [illegible] round it would serve for a discharging aperture.

Mr [illegible] of [illegible] Square, London, recently introduced, under a patent right, a [illegible] which is stated to be especially applicable to the skins of small animals, [illegible] hares, rabbits, cats, and sea rats. Upon reading the specification [illegible] find any thing essentially different from that which is well known [illegible] except that he adds a small quantity of [illegible] tanning: 5 or 6 ounces are mentioned as a proper quantity for [illegible] of the small skins. He commences the process [illegible] from the skins; first taking off the long hair and [illegible] to facilitate this operation, he steeps the [illegible] acid, in very small quantities [illegible] these the skins are suffered to remain [illegible] the hair or the hide is decomposed. After the hair has been removed the skins are to be again steeped in water containing a very small proportion of sulphuric acid in order to raise or thicken them. The tanning is effected by steeping the skins in an infusion of bark, with the [illegible] the same as is practised in [illegible].

Of the numerous substances employed in tanning, oak bark is the chief in [illegible] properties, but from its comparatively [illegible] may be obtained almost every [illegible]. In Russia [illegible] the bark of the black [illegible] bark. Chesnut bark is now [illegible] on the Moselle, has lately employed [illegible] it is reported that by the use of it as a substitute for oak bark [illegible] in much less time; a [illegible] Treves, for the examination of leather so tanned, reported [illegible] equal to it in quality. The *Revue* [illegible] N[illegible], the *marc* of grapes, after [illegible] had been found a most [illegible] in tanning. After the skins had been prepared [illegible] they were placed in [illegible] pits containing the *marc* instead of bark, the same were completely tanned in from thirty-five to forty days. The [illegible] the process, reducing the cost, improving [illegible] strength. [illegible] the substances of recent introduction [illegible] known in commerce by the terms *gum* [illegible] richest in tannin matter. This tree grows in [illegible] in New South Wales, where [illegible] have been made for [illegible] process. The leather made [illegible].

The experiments of Sir Humphry Davy show, that 1 lb. of catechu is nearly equal [illegible] of the bark of the Leicester willow, 8½ [illegible] of the bark of the Spanish chesnut, 18 of elm bark, and 21 of [illegible] bark, with respect to the tannin contained in them. He observes, that [illegible] in weak infusions of bark, appears to be better in quality [illegible] stronger than when tanned by strong infusions; and [illegible] the extractive matter they imbibe. This principle, [illegible] the quality of the material employed in tanning; and galls, which [illegible] a great deal of tannin [illegible] hard leather very liable to crack, from their deficiency of extractive matter.

The preparing and dressing of lamb's, sheep's [illegible] and other thin hides, closely resembles [illegible] thicker or larger kind already mentioned, but it usually forms a distinct branch of business: and it is one that requires [illegible] skill and nicety of manipulation, to produce goods of the desired quality. The processes vary in many particulars, according to the

he commodity. This branch of the leather manufacture supplies the emand of white and dyed leather, the (so called) Spanish and Morocco different colours and qualities, and a great variety of thin leather for urposes. Of these, the white leather alone is not tanned, but is pre- he process called *tawing*; but the coloured leather receives always a hich is usually effected by sumach, independently of the other dyeing The previous preparation of each, or that in which the skin i cleansed, and reduced to the state of simple membrane, in which l *pelt*, is especially the same, whether for tawing or dyeing. The erforming these operations at Bermondsey, adjoining London, is as Lamb skins, are first soaked for a time in water, to cleanse them from t and blood, then put upon the beam, (a half-cylinder of wood, covered r leather,) and scraped on the flesh side with the semicircular blunt two handles, used for this operation; they are then hung up in consi- mbers, in a small close room heated by flues, where they remain to a given time, during which a thick slime works up to the surface of nd the wool is loosed, so that it readily comes off with a slight pull. is then returned to the beam, the wool taken off and preserved, and ie worked off with the knife, and the rough edges pared away. The t put into a pit filled with lime water, and kept there from two to six ording to the nature of the skin; this process has the effect of stop- utrefaction of the skins, and renders them thicker and harder; after again worked upon the beam, and much of its substance is pared all inequalities smoothed with the knife. Much skill and judgment d in these operations; on the one hand, not to endanger the substance by the putrefaction, and on the other hand, to work out every par- slime, the least of which, if retained, will prevent the skin from dressing subsequent processes, and from taking the dye uniformly and well. again softened and freed from the lime, by being plunged into a vat of ater, and kept there for some weeks in a state of gentle fermentation, sionally returned to the beam. All the thickening produced by the s removed, and the skin in this highly purified state, is a thin exten- membrane, called a *pelt*, which is a condition that adapts it to any t operation, of tawing, or dyeing, oil-dressing, or shammoying.

thod of bringing kid and goat skins to the state of pelt, is nearly the r lambs, except that the liming is used before the hair is taken off, the r only employed by plasterers, is of little value; but the lamb's wool, ore valuable, would be injured by the lime. Kid's skins, being of a ure than lambs', take a long time in tanning.

elts are to be *tawed*, they are then put into a solution of alum and rm water, in the proportion of about three pounds of alum, and four salt to every 120 middle sized skins, and worked therein till they bed a sufficient quantity. This again gives the skin a remarkable thickness and toughness. The skins are then taken out, washed in l then again put into a vat of bran and water; and allowed to ferment , till much of the alum and salt is got out, and the usual thickening by them is for the most part reduced. They are then taken to a , with a stove in the middle, and stretched on hooks, and kept there till The skins are thus converted into a tough, flexible, and quite white n t to give them a glossy finish, and to take off the harshness of feel ing, they are again soaked in water, to extract more of the salt, and large pail containing the yolks of eggs beat up with water. Here are trodden for a long time, by which they so completely imbibe the of the eggs, that the liquor above them is rendered almost perfectly fter which they are hung up in a loft to dry, and finish by glossing rm iron. The essential difference between tanning and tawing there- at in the former case the pelt is combined with tan or other vegetable nd in the latter with something that it imbibes from the alum and ably alumine.

rocco leather (so termed from its being the same description of article

as was formerly imported from the kingdom of Morocco,) is distingui two kinds; one being made from deers' and goats' skins, which kind the most durable and beautiful in appearance, and often called "*real* M the other from sheep skins, which, from being only about one-third th the real, and being artfully made to imitate the other, by the dres finish, is most extensively used for book-binding, shoes, coverings to d niture, and an infinite variety of purposes. The leather is thus mad skin, cleansed and worked in the way already described, is taken from water, and the thickening thereby occasioned is brought down, not liquor, as in tawing, but by a bath of dogs' or pigeons' dung diffused where it remains until sufficiently suppled, and until the lime is quite and it becomes a perfectly white clean pelt. If intended to be dyed re other colour, the opposite edges of the skin are brought together and very tight, forming an irregular close bag, with the grain side of the wards, as this side alone receives the dye; therefore, if there are any the skin, they are also sewn up that the dye may not get inside the dye both sides of the skin. The temperature of the bath should not b than the hand can bear, when the skin bags may be thrown in, wh upon the surface, the dyer working them about with a rod until th imbibed the dye uniformly. The proper management of this process much skill and experience, some colours, particularly the compound, two or more baths to obtain the required hue. The cochineal and Br are usually passed through a weak bath of saffron, which heightens the l of the colour, and gives an agreeable odour to the skins. After dy skins are tanned in a large vat containing a warm infusion of sumach, they are kept for some hours, until they are sufficiently tanned. Th that are intended to be black, are first tanned in sumach, without any dyeing, as the sumach (or the gallic acid contained in it) acts as a mo strike a black colour by the addition of a solution of iron, which is rub them by a workman with a stiff brush.

The next processes are polishing and graining; they are perform by hand or by machinery, and are technically called *finishing*. W formed by hand, the workman takes a skin and lays it before him inclined mahogany table, the highest side of which is upon a level workman's middle, and the opposite side about a foot lower, in order weight of the body may assist in giving effect to the polisher; this is glass cut into polygonal surfaces, with which the workman, holding it his fists, rubs the surface of the skin uniformly from the higher pa table to the lower, the weight of the upper part of the body being the force applied: the skin being held by its edges overhanging the highe the table against which the man presses during the work. This pol glazing of the surface, (which greatly improves the appearance of the being done, the graining is proceeded in. For this purpose the employs a ball of hard wood, usually box or lignum vitæ, around whi torially, are cut a series of equi-distant parallel grooves, producing th alternating series of projecting parallel ridges; with these ridges the scores the skin all over in parallel lines, and when that is done he shifts little, so as to cross the first lines at a very acute angle, with his ridged ba he does uniformly over the skin, and thus produces a regularly corrugate

In the application of machinery to the operations of polishing and the principal difficulty to be overcome was to make the action acco itself to the varying thickness, hardness, and texture of the skin; for t sary quantity of force to grain the firm parts of the skin, would, if a the tender parts, tear them; and unless the machine possessed a ver degree of flexibility, the prominent parts would get severely rubbed while the depressed parts would not get touched, or be but slightly ac We shall annex a description of the earliest invention (about twenty- ago) for this purpose, which has been in use ever since.

Hebert's Patent Leather-finishing Machine.—This essentially consists stiff circular frame or wheel, 8 feet in diameter, revolving horizont

...ia. On the under side of the periphery of this wheel are fixed, in carriages, a series of circular polishers or grainers, according to the ...e work to be done: the carriages being provided with proper means ...g the position of the rubbers with great exactness, and of readily ...xing, and changing them, according to circumstances. These rub...ir revolution, pass directly over a series of eight tables, circularly ...underneath them. The upper surfaces of the tables are all brought to ...rizontal plane, parallel to the plane described by the under surfaces ...ers in their revolution. The skins to be polished or grained, are ... these tables, one on each, and if they were all perfectly equal in ...tenacity, and texture, very little more would be required to make ...chine work; but as the skins differ in every possible degree in those ...he tables are mounted upon elastic bearings, and are further sup... a lever to each, at the end of which lever is a step or treadle, ...e workman stands, either with both feet or with one foot only, that ...per the force according to circumstances, or the nature of the work ...ation; and when he steps entirely off the lever, the table falls below ...f the range of the rubbers, and therefore out of action. When the ...he step, the surface of the table over which the rubbers act, approaches ... hundredth part of an inch of the plane described by the lower sides ...ers, so that when a skin is interposed, the thinnest parts are operated ... with a force as slight as the workman pleases, and the thick and ... with any greater pressure at the direction of the operator. For ...nd preserving a very true plane on that part of the table over which ...rs and grainers traverse, that portion of it is made of brass with ...screws underneath. The extremities of this metallic portion are gra...ed a little from the true plane to prevent the rubbers *striking* the ...y pass in rapid succession on to or off their work. A workman, who ...re each table, spreads the skin upon it, and keeps constantly shifting ...h rub it receives, till it has all been operated all over alike in parallel ... then turns the skin a little sideways, so that the grainers pass over ...us lines at an acute angle, as before mentioned in the hand work. ...g and graining of leather may thus be performed in an equal, if not a ...anner to that of hand finishing, and at about one-tenth the cost. Owing ...and rubbers not being properly chamfered off towards their edges, and ...gular movements of the skin over the table, by unpractised operators, ...were at first occasionally scored, showing in a disadvantageous manner ... lines upon its surface. These defects were soon remedied by atten... points mentioned, and the work afterwards executed was upon the ... superior description; for it will be readily conceived, that with so great ... feet (the wheel being 8 feet in diameter), the curvilinear form of the ...es together, and crossing each other, so as to form minute lozenge-...jections, would appear to be straight; and that if a scratch be made ...in, it would equally mar its beauty, whether it were in a *straight* or ...ne. However, a gentleman of great talent (Mr. Joseph Ellis) subse...nceived the idea of a finishing machine that would groove the skin in ...ion, and it was constructed with great accuracy and beauty of work... by Mr. Alexander Galloway, who joined Mr. Ellis in a patent for it. ...his machine was ever brought to work to advantage the writer is not ...e has no recollection, but it appears to him to be of a character ...f notice in this place.

...*Machine*.—Instead of a great wheel revolving horizontally, like Hebert's, ...ed a little wheel (about 30 inches diameter), which revolved vertically ...ly; on the outside edge of which were fixed, in suitable carriages, ...s and grainers, provided with proper adjustments. The table on which ...were laid was a hollow segment of a circle, of the same radius as that ... by the rubbing surfaces of the glazers and grainers; thus the skins ...ed with right lines by a curvilinear motion, owing to their lying in a ...e. The specification of this invention, very ably and fully described, ... the thirteenth volume of the *Repertory of Arts*, Second Series, to

which the reader is referred for the details; an inspection of the drawings in which inclines us to think the machine may have failed from two causes; *First*, the finisher incurs great risks from blows by the revolving tools as they successively descend into the hollow curve wherein the skin is operated upon. He has to look *down* this curve to see his work; and as the view is a very unfavourable one for examination, he might inadvertently put his head too near and get a fatal blow. If a guard were put up to prevent such an accident, it would be in the way, and obstruct light in a situation where more is wanted. *Second*, The necessity of extraordinarily accurate workmanship to make a perfect adjustment of the concave surface of the table, with the curve described by the revolving tools. A *third* objection will probably lie against the *direction* in which the table is brought into or goes out of action; it is made to slide in a horizontal and tangential line with the lower side of the circle described by the tools, consequently the lower extremity of the table comes into action first, which must subject this important part of the machine to shocks very unfavourable to the preservation of a perfectly true bearing. We submit that it would be better to make the table move in a radial line to the centre of the wheel, or at the least, in a tangent to a very small inner circle.

Splitting of Hides and Skins.—We have already noticed that after a sheep skin, or other raw hide, has been cleansed and purified from all extraneous matters, it undergoes a scraping and paring of its inner surface to give it a thinner or more uniform substance; by these processes the subsequent dyeing and tanning are greatly facilitated. This reduction of the substance was once entirely, and is still partially, executed by means of a knife in the hands of workmen, some of whom are so dexterous as to be able at every stroke of the knife to take off a shaving the whole breadth of the beam. The utmost exertion of ordinary skill was, however, insufficient to prevent the frequent recurrence of unlucky cuts, by which the value of the skin was considerably lessened, and the pieces sliced or scraped off were only applicable to the making of glue. But by the introduction of machinery to effect this operation the skin is now divided throughout its entire substance into two parts of equal extent, one of which is subsequently converted into leather, and the other into parchment; at the same time the upper or hair side of the skin is thereby made smoother and of a more uniform thickness, which enhances its value. During the last forty years a variety of highly ingenious machines have been constructed for this curious and apparently difficult operation. It is now about twenty-seven years ago that we saw a beautiful machine for this purpose at work in the extensive manufactory of the Messrs. Bevington, near Bermondsey, the peculiar or essential features of which we shall be able to afford the reader an idea of in a few words.

Bevington's Splitting Machine.—In a stout A framing were mounted two horizontal rollers or cylinders, which were made to revolve in opposite directions by means of pinions at one of their extremities gearing into each other. The lower roller was solid and turned concentrically upon its axis; over this roller the skin in its wet state was spread out across its breadth, with its even side next to the roller, the uneven or flesh side being uppermost. To give a uniform pressure to the uneven side of the skin, a species of flexibility was conferred to the upper roller by compounding it of a series of circular metallic plates, like a roll of penny pieces, but which were about half an inch in thickness, and three inches in diameter; each plate had two holes, one in the centre through which passed a fixed axis, smaller than the hole, in order that the plates might have a certain degree of play or eccentricity of motion; the other hole was about midway between the centre and the circumference, through which a rod passed freely, the extremities of which were so fixed to flanges at the extremity of the roller as to perform a planetary motion round the common centre of the plates; and as the rod passed through all the circular plates, they were all carried round with it, while the centre of motion of each individual plate, owing to the play given to them, were constantly being changed in proportion to the thickness of that part of the skin pressed against it, by the revolution of the lower inflexible roller. As the skin emerged from the bite between

e rollers, it came in contact with the straight edge of a very sharp knife, to ich a constant sawing-like motion was communicated by the revolution of a ank. The circular plates, which were turned with great truth, were not essed fast laterally, but kept slack and well oiled, their sides sliding freely gainst one another, so that each individual plate pressed simply by its own avity, in order that however varied the thickness of the skin, the pressure ould be uniform over the whole surface.

By this arrangement it will be observed, that the upper portion of the skin the uneven one, and that the lower portion is the perfect skin, smooth, and niform in all its parts. As a curiosity, and to show the capability of the machine, eep-skins were sometimes split into three parts of equal area; the outside one eing applicable to the preparation of several kinds of leather, the middle to e making of parchment, while that on the flesh side, from its inequality of ickness, and want of firmness, was only applicable to the making of glue.

Stott's Splitting Machine.—About the same period of time that we saw the achine at Messrs. Bevington's (which, we should have added, was said to be e invention of Lieut. Parr), another machine was brought under the notice of e Society of Arts, who rewarded the inventor, Benjamin Stott, of Bermondsey street, with the sum of twenty guineas for the communication of the same. It s described with engravings in the twenty-fourth volume of the Society's *Transactions*, of which we subjoin the following brief account:—The skin is rapped round a cast-iron barrel, having wooden ends, over which the sides of he skin are overlapped and made fast by pins stuck through them into the wood. There is also a longitudinal groove in the barrel for the insertion of a locking ar with points that holds down the ends of the skin underneath them. The arrel, with the skin so stretched upon it, is made to revolve by the agency of an attached cord passing over a pulley, and having a weight appended to the other end. The axis of the barrel rests upon two anti-friction rollers, which turn in a slip of brass fixed to the wooden frame of the machine; and the weight is only just sufficient to overcome the friction of these parts, and to bring up the skin against the edge of the knife as it cuts by the traversing motion of a frame to which it is screwed.

Revere's Splitting Machine.—By a reference to the eighteenth volume of the *Repertory of Arts*, Second Series, we find the specification of an English patent granted to Mr. Joseph Warren Revere, an American, "for a new and improved method of splitting hides and shaving leather," dated 1810, in which the patentee declares his method to "consist in the use of a *fixed or stationary* knife, and in so placing and confining it as to meet the hide or leather before it escapes from the action of the forcing cylinders; and also in the construction of, and the manner in which, a powerful action is obtained from the forcing cylinders, whereby the hide or leather, as it passes through, has not room to deviate, but must necessarily be forced and proceed right onward to the knife, and undergo the splitting and shaving intended. By this machine the hides or leather are split or divided into any thickness required, and with great expedition; and when divided or split, are left with smooth surfaces, and free from any marks of the knife." Thus far saith the record of the patentee; but whether the motion of the knife can be dispensed with, and yet produce good work, is a point that may still be questioned. We can conceive the possibility of its answering to split a skin, were it of uniform thickness; but it is otherwise, and the patentee has made no provision in his machine to accommodate that circumstance. He has a feeding roller set all over with points, which conducts the skin between a pair of *inflexible* rollers, "grooved or fluted longitudinally upon the surface of both of them;" and it is these that are said to force the skin so that it cannot deviate from passing on each side of the edge of the knife. But it seems to us evident that a sheep skin, varying as it does in its thickness, must be absolutely crushed in its thick parts before the thin parts can be compressed firm enough to be cut by a mere push, especially at that distance that a knife edge can approach a *fluted* roller; and as the *pressure* must be unequal where the surfaces of the skin are not parallel and the rollers are, it seems to follow that the skin would be cut into ridges in the direction of the motion of the skin.

We shall finish our account of this curious branch of art by the dews of a novel and recently patented invention for the purpose, which has furnished to us by that eminent draftsman, Mr. C. Davy, of Furnival's London.

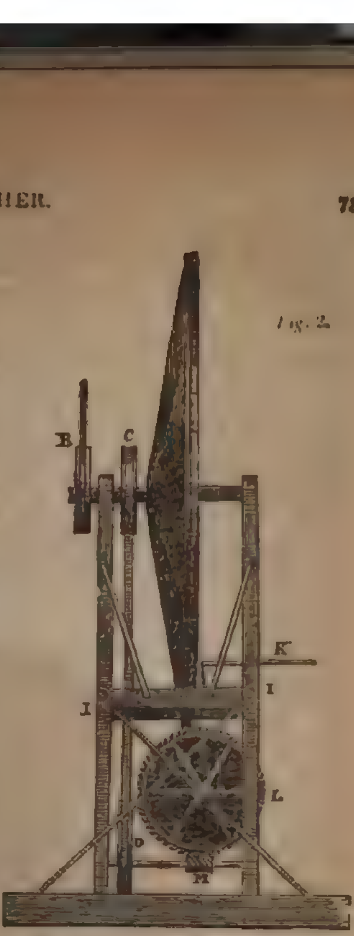
Duxbury's Patent Skin Splitting Machine.—Mr. Davy states that it has found that the parallel sides of a cylinder are not adapted for the smooth sion of a skin upon them: and that the consequence of compressing it to such surfaces is to form little wrinkles, which the straight knife cuts thr and thereby produces holes. To obviate this defect, and also that of the produced by the reciprocating action of the knife, a variety of machine been projected, in which the cutters partook of a rotatory motion, b mechanical difficulties attending the application of the principle have their abandonment. Mr Duxbury has, however, by a novel position cutters, and a peculiar form of the bed over which the skin is laid, over all those difficulties, and the skins are cut by one continuous smooth slic the whole surface. The machine, as shown in the subjoined engravings,

Fig. 1.

and 2, essentially consist of a great vertical wheel A, 17 feet in diameter posed of wood, strengthened by iron arms; the axle of which turns in pl blocks, upon a strong framing I I. On the periphery of this wheel are twenty-five thin plates of steel, ground to a fine edge, and so closely fit to form a complete circular knife, projecting a short distance *horizontall* the side of the wheel. The skin to be split passes over the drum E, instead of being straight sided longitudinally, has a curved concavity same radius as the curve described by the revolving knives, or cor

-cular knife before mentioned; his -um is made of wood externally, -ed upon an iron frame, and turned the true curve. A slit is cut lon-itudinally on the surface of the -rum, wherein the edges of the skin -e secured; and the skin is kept -tended during the operation by -eans of a cast-iron frame F, called -y the patentee the *governor*, and -own in the following figure (3), on larger scale. The ends slide in -ides in the upright posts of the -aming, to which it may be adjusted -d fixed, and it is provided at K -ith a lever and chain for raising or -wering it from its position, as may -e required. The skin as it is split -asses through the opening H, and -hence on to the roller G, whereon it -s wound. Motion is given to the machine by a band passing round the pulley B, which actuates the pul-ley C on the same axis; and this, by means of an endless band, turns the pulley D; on the axis of the latter is an endless screw M, which turns the wheel L on the axis of the drum; thus motion is communicated to the whole. In splitting small skins, several drums, such as that described, are arranged under the lower side of the great cutting wheel

Fig. 2.



The patentee also employs occasionally

Fig. 3.

a "governor" of a different kind, to compensate any irregularity that there may be in the surface of the drum; it consists, as shown in the annexed figure (4), of a series of pieces of metal hanging loosely on a bar, so that they may, simply by their gravity, press with a uniform force upon an irregular surface.

Fig. 4.

Currying Leather.—This operation, which usually forms quite a distinct business, consists in a peculiar mode of dressing or preparing leather for boots, shoes, harness, and a variety of other things. The dressing of a calf skin for the upper-leathers of shoes, will give a general idea of the process. The offal

parts, such as the head, tail, and shanks, being first taken off, (which is called rounding the skin,) it is soaked in a tub of water preparatory to shaving, which is performed upon a beam. The beam is a post fixed in an inclined position, and faced with lignum-vitæ, about 8 inches broad. The knife is a stout rectangular blade, about 12 inches long and 5 inches wide, with two edges; one end has a straight handle, and the other a cross handle in the direction of the plane of the blade. A coarse and a fine grit whet-stone are used to bring up the edge of the knife, which is afterwards turned to a "wire edge" by means of a steel instrument, which the workman constantly holds between his fingers. The mode of using the knife has already been noticed. In order to keep the substance of the skin equal, the man frequently examines it in the course of shaving in every part, by passing it double between his fingers; and when sufficiently reduced, he throws it a second time into a tub of cold water to be scoured and extended; for this purpose it is laid upon a stone table, to which the flesh side adheres, and is there worked with the edge of a small square stone fixed in a handle: pumice stone is sometimes used. With a brush the skin is cleansed from a substance called the *bloom*, which all leather, tanned with bark, is found to contain. After being thoroughly cleansed and distended while in its wet state, it is stuffed with a mixture of two parts cod oil, and one part tallow, called dubbing, which is applied to both sides of the skin, but chiefly on the flesh side. It is then hung up to dry, by which the moisture evaporates; and the oil, which cannot be dissipated by mere exposure, gradually takes the place of the moisture, and sinks deeply into the pores of the skin. The leather is next boarded or bruised, by a grooved piece of wood (like a crimping board) that is fastened to the hand by a strap; with this the skin is doubled and worked until made very flexible; it is next "whitened," that is, lightly shaved over again, by which the flesh side is well cleaned, and it is brought into a proper state to receive the colour used in waxing. Before it is waxed, however, it is boarded a second time, when it is in that state called finished russet, in which state it can be best preserved: therefore, until it is wanted for sale, the subsequent operations called waxing are left undone. The "colour," or blacking, is a composition of oil, lamp black, and tallow, which is well rubbed into the flesh side with a hard brush, great care being taken to keep the flesh side clean. A coat of strong size and tallow is then laid on with a soft brush; it is afterwards rubbed with a smoothing glass; and lastly, it receives the finishing gloss from a little thin size laid on with a sponge. After the first coat of size the skin is laid up to dry and incorporate, and a lump of hard tallow is rubbed lightly over the surface; the skin is thus completely finished for the consumer; and leather so dressed is found superior in point of appearance and durability to any other method. The curriers also blacken leather on the grain side, which is done by rubbing it with a solution of copperas, which, combining with the gallic acid of the tan, produces a black.

Russia Leather is prepared in Russia by a series of processes not essentially differing from our own. The tanning material is, however, seldom oak bark, the bark of the black willow being preferred; and where this cannot be obtained birch bark is the next in request. Their dyed leather is usually red or black. For the red, the hide is first soaked in alum water, and then dyed with Brazil wood. The black is given, as usual, with an iron liquor. The leather is then smeared with birch tar, which gives the peculiar smell so much prized (and which, when used for book-binding, has the valuable property of protecting the book from worms), and is finished by various other manipulations. The streaked or barred surface is given to the leather by a very heavy steel cylinder, wound round with wire, which makes the indentations.

Saffian or Dyed Maroquin Leather, of excellent quality, is extensively prepared at Astracan and other parts of Asiatic Russia. Only bucks' and goats' skins are used for this purpose, and the favourite colours are red and yellow. The general method of preparing the pelt is the same as in this country for the dyed Morocco leather; that is, by lime, dog's dung, and bran. Honey is also used after the branning. The honey is dissolved in warm water; and some

s. The yellow saffians are dyed with the berries of a species of he Avignon berry answers the same purpose), or with the flowers of iamomile.

rocco Leather, as prepared from goat skins at Fez and Tetuan, is bed by M. Bruffonet in the *Bulletin des Sciences*. The skins are first he hair taken off, limed, and reduced with bran, nearly in the same y described for the English Morocco leather. After coming from the are thrown into a second bath, made of white figs mixed with water, iereby rendered slimy and fermentable. In this bath the skins remain : days, when they are thoroughly salted with rock salt alone (and not nd alum), after which they are fit to receive the dye, which, for the hineal and alum; and for the yellow, pomegranate bark and alum. are then tanned, dressed, supplied with a little oil, and dried.

s.—This singular and valuable leather is a manufacture almost Astracan, where it is prepared by the Tartars and Armenians. For agreen, only horses' or asses' hides are taken, and it is only a small the crupper, along the back, that can be used for this purpose. This immediately above the tail, in a semicircular form, about 34 inches crupper, and 28 along the back. These pieces are first soaked in the hair is loose, and can be scraped off; and the skin, again soaked, or shaved so thin, as not to exceed a wetted hog's bladder in thick- till all the extraneous matter is got off, and only a clean membranous ns. The piece is then stretched tight on a frame, and kept occa- wetted, that no part may shrink unequally. The frames are then a floor, with the flesh sides of the skins undermost, and the grain sides d over with the smooth, black, hard seeds of the alabuta, or goose-foot, lium album,) and a felt is then laid upon them, and the seeds trodden into the soft moist skin; the use of this is, to give the peculiar roughed surface, for which shagreen is distinguished. The frames, eeds still sticking to the skins, are then dried slowly in the shade, till will shake off without any violence, and the skin is left a hard, horny with the grain side deeply indented. It is then laid on a solid block, ith wool, and strongly rasped with two or three iron instruments (the forms of which it is unnecessary to describe), till the whole of the is shaved, so that the impression of the seed is very slight and uni- ie skins are then softened, first with water and then with a warm re, and are heaped warm and wet upon each other, by which means indented by the impression regain much of their elasticity; and it none of their substance by paring, rise up fully to the level of the

application of an elastic coating and varnish to substances of a pliable such as all kinds of cloth, whether cotton, linen, woollen, or felt. Wh material is required to have flexibility, the composition is to be made of t lowing ingredients :—

Common glue size	8 parts.
Boiled linseed oil	4 „
Lamp black	1 „
White lead, ground fine . . .	2 „
Pipe clay, ditto	2 „

These are to be melted and well blended together over a fire. At fi size is to be melted, then the oil is to be added in small quantities at a next the lamp black, white lead, and pipe clay, during which it should b stantly stirred; the composition is then complete. The cloth being prev strained upon frames, the composition is spread on it evenly and smoothl a pallet knife, working it well therewith into the interstices of the cloth, it shall be thoroughly saturated with the composition. The first coat i to be dried, either in the air, or in a warm room, by hanging up the frame being taken that they be not exposed to much heat. When thoroughly dri hard, a second coat may be laid on and dried in a similar way; also a th fourth, or a fifth, if required of great substance, which should all be spre as smoothly, and every successive coat be hard before the next is la This material, the patentee states, is chiefly intended for the manufact patten ties, and therefore he cuts it into strips previously to varnishing i passes them between polished metal rollers to give them a smooth even s Some drying linseed oil, or other suitable varnish is then brushed ov strips; mixing with the vanish any required colour to give the artic desired tint. The next operation is the cutting up the material into the sizes for patten ties, and finishing the same as usual under a screw with dies.

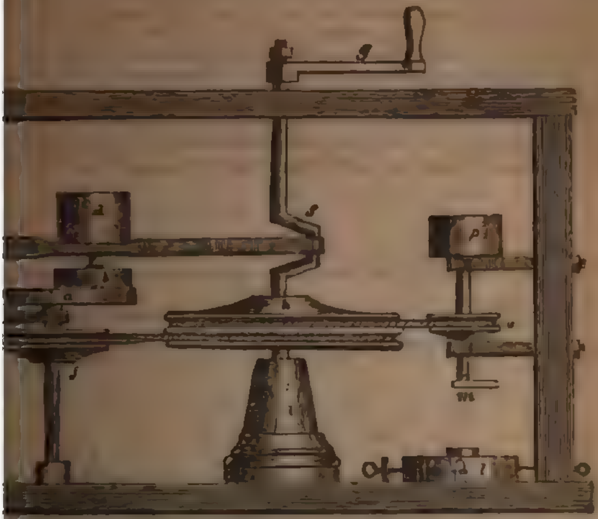
For coach tops, and other purposes where flexibility is not necessar quantities of the pipe clay, white lead, and size, may be increased, accord the nature and use of the article to be manufactured of it. For smooth down and polishing such large pieces of the cloth as will not pass throug roller press, the common method of rubbing with pumice stone, tripoli, adopted previous to varnishing.

Hancock's Patent Substitute for Leather.—Instead of using cloth, Mr. Gunby's patent just described, Mr. Hancock merely hackles or car fibres of flax, cotton, &c. by which they are drawn out into layers of a s thickness; they are then felted together in a trough of water, and after pressed between cylindrical rollers. Over this fabric, liquid caoutch Indian-rubber is to be spread uniformly by means of a spatula. Whe caoutchouc has sufficiently solidified, it is to be again pressed, then r another coat of the resin, and again pressed.

LEMONS, Salt of, is the native salt of sorrel, the super-oxalate of p and is chiefly used to take the ink-spots out of linen. The effect is pro by the oxalic acid dissolving with facility the oxide of iron in the ink, combinations of which with the gallic acid the colour depends. It can be without any risk of injuring the texture of the cloth.

LENS, in Optics, a piece of glass, or other transparent substance, havi two surfaces so formed that the rays of light have their direction chang passing through it; so that they either converge, tending to a point beyo lens; or diverge, as if they proceeded from a point before the lens; or be parallel, after converging or diverging. Some lenses are convex, that is, t in the middle than towards their circumferences; those that swell on both are called double convex lenses; some are concave, or thinner in the m some are plano-convex, or flat on one side and swelling on the other; so plano-concave, or flat on one side and concave on the other; and lastly, are concave on both sides. According to some opticians, the greatest dis

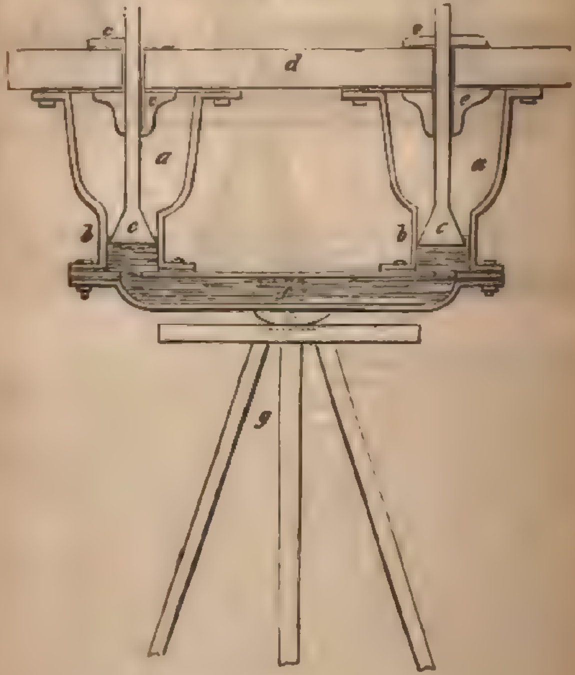
... an inch, if it exceed that thickness they do not call it a lens, ... glass. Lenses are made either by blowing or grinding. Blown ... globules of glass melted in the flame of a lamp: ground ...ed by grinding and polishing. A variety of simple apparatus ... the processes of grinding and polishing lenses, amongst which ...was recently introduced to the notice of the members of the ...ics' Institution, by Dr. Birkbeck, in one of his interesting lectures ...echanical inventions. *a* shows the edge of a circular lap or ...rinding flat glasses upon; *b* a circular tool or block, upon the ... which the glasses to be ground are cemented; *c* is a recipro... box containing any weighty matter; *e* a long morticed aperture



...hrough which the bar *c* freely works; *f* a crank; ... double pulley wheel, the axis of which rests in ... a single pulley wheel. Now on turning the ...inch *g*, the bar *c* gives to *b* an eccentric motion; ... *b* on the surface of the lap *a* being increased or ... pleasure by increasing or diminishing the load ... It should be noticed, that the cord which passes ...ley *h* is crossed previous to its embracing the ... pulley *i*, consequently a motion is given to the ...e of that given to *b*, which is considered to pro... effect of grinding. The apparatus described is ... producing of plane surfaces to optical glasses; ...us on the other side of the machine, is at the ... similar arrangements, employed in grinding con... surfaces. For this purpose a variety of laps ... similar to those delineated in the margin, are so ... on the bed *l*, which bed is adjustable by four ...ews. The pulley *o* is driven by another band ... *h*, and the required pressure given by another ... the use of the lower tool *t* was not apparent to ...ok our sketches), but we conjecture it is intended

to fix a diamond at the point, for cutting the glasses out of a true circular figure, by being screwed on at *m*. The several tools used are adapted for ready changing, that the operations may be performed with celerity. See OPTICAL INSTRUMENTS.

LEVEL. An instrument employed for obtaining a line or plane parallel to the plane of the horizon. One principal use of the level is to find the difference of elevation of two or more planes, for the purposes of conveying water, constructing roads, &c. from one place to another. Among the various contrivances employed for constructing instruments for finding the level, the following are some of the principal. The *water level*, the horizontal line by the surface of the fluid:—The most simple kind is nothing more than a long wooden trough, filled with water, such as is described by Vitruvius, under the name of the *chombates*. Another level of this kind consists of two cups, fitted to the ends of a straight cylindrical tube, of an inch in diameter, and three or four feet long, by which the water freely communicates from one cup to the other; the tube is movable on its stand by means of a ball and socket, and thus the surfaces of the water, when the cups are equally full, show the line of level. Two glass cylinders, of three or four inches in length, may be substituted instead of the cups, being fastened with wax or mastic to the ends of the tube: this machine should be filled with coloured water. A very simple quicksilver level, invented we believe by Mr. Parker, of Sweeny, is delineated in the annexed cut, which it is said is



much used in the north of England for irrigation, draining, &c. and does not cost as many shillings as the usual instrument employed costs of pounds. *a a* are two funnels or basins cast in iron from the same mould, their lower ends are concave cylindrical, and bored so as to be of exactly equal diameters; they

d down by flanges to the tube *f*, which is flat at top, and through which flows. *c c* are two floats also exactly equal to each other in length, lower surface. A hole, one-eighth of an inch in diameter, is drilled of the funnels for introducing the quicksilver, and afterwards closely a fine cork; *d* is a mahogany top to the instrument, to which the are screwed; *e e* are collars or guides for the floats, made of lignum- prevent the escape of the quicksilver; *g* is the stand and pivot on rns. Between all the junctures leather washers are introduced, to tight.

this instrument, an observation is made on *the tops of the floats*, they exactly coincide or project equally, shows the ground to be a tal plane; on the contrary, when they differ in height, the ground This mode of *taking an observation* appears to us defective, as the of two surfaces, when upon the same plane, cannot be distinctly would be better to have a circular hole through the tops of the floats, at them from a fixed point on either side: when the two circles they would appear to the eye as only one of a true figure, and denote ; any deviation would be clearly denoted by the circles intersecting and producing a curved figure, with two pointed ends, which would ctly the extent of the alteration required. The simplicity and the instrument permit of its being thrown down, and rolled about taining injury, and any rough unlettered man may use it with may be had, we are informed, of Mr. Batt, Seedsman, 412, Strand,

level, invented by M. Thevenot, the level is determined by means bubble, inclosed with some fluid in a glass tube, hermetically sealed at ds; the case or ruler in which the tube is fixed will be exactly the bubble remains at a marked point at the middle of the tube, being on either side of this mark shows the variation. The glass etimes enclosed in another of brass, the centre of which has a hole large to observe the place of the bubble. The liquor employed such as will not readily freeze, rarefy, or condense, such as oil of secunda, &c. The instrument last described has received many improvements, by the addition of sights and other apparatus s contrived a level, carrying a telescope instead of plain sights, sses some advantages above the common sort; and his invention improved upon in a variety of ways by the instrument makers. A this kind, containing the principles both of the barometer and ther- was proposed by the late Dr. Desaguliers; but though in theory it d, yet in practice it was found very inaccurate. (*Philosophical Trans-* XXXIII. p. 65.) Amongst the various *spirit levels* that have been that contrived by Mr. Hadley deserves to be noticed; it is adapted nt for taking the meridian altitude at sea when the horizon is not description and drawing of this useful instrument may be seen in *Transactions*, Vol. XXXVIII. The *reflecting level* is the next to d. it represents the object as reflected upon a long surface of water, ted position, and was invented by Marriotti. Another kind, which Cassini, consists of a polished metal mirror, placed at a small dis- the object-glass of a telescope, suspended perpendicularly; this set at an angle of 45°, the perpendicular line of the telescope will orizontal line, that is, a line of level. The *plumb* or *pendulum level*, Picard, shows the horizontal line by means of a line cutting the e perpendicularly; it consists of two legs, joined together at right a telescopic sight, and other apparatus; the whole is fixed on a ans of a ball and socket. The *balance level* is an instrument sus- a ring; and when in equilibrio, two sights, properly fitted to the will show the line of level. The *carpenter's, bricklayer's, or paviour's* of a long narrow board, to the middle of which is fixed, perpen- nother board, broader and shorter than the former, and having a hrough its middle, cutting the first mentioned board at right angles.

A plummet being suspended from the top of the upright piece shows th base is horizontal when its line, and the line drawn from the point of s sion, exactly coincide. The *mason's level* is composed of three pieces, f together in the form of an isosceles triangle. From the vertex of this a pl is suspended, which, when it hangs directly over the mark in the centre base, indicates that the base is exactly in the line of level.

LEVELLING. The art or act of finding a line or plane parallel plane of the horizon. The uses to which this art applies, are the detern the height or depth of one place with respect to another; the laying grounds, regulating descents, conducting water, &c. It is necessary to p that two or more places are, strictly speaking, on a level, when they are e distant from the centre of the earth; and a line, of which all its const points are equally distant from that centre, is called *the line of true level.* this line, consistently with the round form of the earth, must evidently be a similar and parallel to the earth's circumference, and concentric with it. the line of sight employed in such operations as are not on an extensive differs from the line above described, being in effect a right line or tang the earth's circumference, and is called *the apparent line of level.* But th ference, as we have already remarked, need not be attended to in oper upon a confined scale, such as sinking of drains, paving of walks, or conv water to short distances, &c.; but where the operations are required carried to a considerable extent, such as the construction of canals of miles in length, the distinction between the true and apparent level must sarily be attended to. The difference between the true and apparent leve be readily found from a property of the circle, demonstrated by Euclid. (Book III. Prob. 36.) In one mile this excess of the apparent abo true level will thus be found to be 7.9618, or almost eight inches. B proportioning the excesses in altitude according to the square of the dist the following table is obtained, showing the height of the apparent abo true level for every one hundred yards of distance on the one hand, and a quarter of a mile to fourteen miles on the other.

Distance in Yards.	Difference of level in Inches.	Distance in Miles.	Difference of level in Feet and Inches
100	.026	¼	0.0¼
200	.103	½	0.2
300	.231	¾	0.4¼
400	.411	1	0.8
500	.643	2	2.8
600	.925	3	6.0
700	1.26	4	10.7
800	1.645	5	16.7
900	2.081	6	23.11
1000	2.570	7	32.6
1100	3.110	8	42.6
1200	3.701	9	53.9
1300	4.344	10	66.4
1400	5.038	11	80.3
1500	5.784	12	95.7
1600	6.580	13	112.2
1700	7.425	14	130.1

This table is adapted to several useful purposes. Thus, *first*, to fi height of the apparent level above the true at any distance. If the give tance is in the table, the correction of level is found on the same line with it at the distance of 1000 yards, the correction 2.57, or 2½ inches nearly; the distance of 10 miles is 66 feet 4 inches. But if the exact distance

he table, then multiply the square of the distance in yards by 2.57, divide by 1,000,000, or cut off six places on the right for decimals, re inches; or multiply the square of the distance in miles by 66 feet and divide by 100.

y. To find the extent of the visible horizon, or how far an observer om any given height, on a horizontal plane, as at sea, suppose the observer, on the top of a ship's mast at sea, is the height of 130 feet water, he will then see about 14 miles round; or from the top of a ne sea-side, the height of which is 66 feet, a person may see to the f nearly 10 miles on the surface of the sea. Also when the top of a light in a light-house, or such like, whose height is 130 feet, first the view of an eye on board a ship, the table shows that the distance p from it is 14 miles, if the eye is at the surface of the water; but if of the eye in the ship is 80 feet, then the distance will be increased 11 miles, making in all about 25 miles in distance.

. Suppose a spring on one side of a hill, and a house on an oppo- with a valley between them, that the spring seen from the house, a levelling instrument on a level with the foundation of the house, pose is at a mile distance from it; then is the spring eight inches above evel of the house; and this difference would be barely sufficient for to be brought in pipes from the spring to the house, the pipes being e way in the ground.

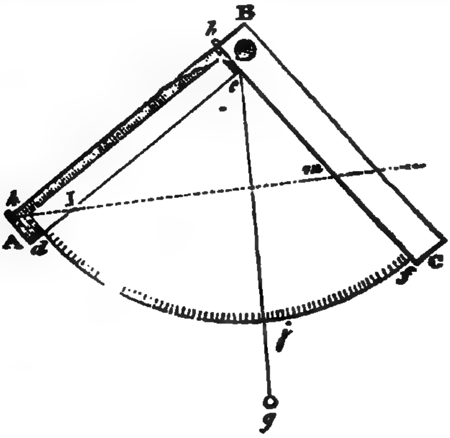
y. If the height or distance exceed the limits of the table, then e distance be given, divide it by 2, or by 3, or by 4, &c. till the comes within the distances in the table; then take out the height to the quotient, and multiply it by the square of the divisor, that is, , or 16, &c. for the height required. Thus if the top of a hill is just e distance of 40 miles, then 40, divided by 4, gives 10, to which in the wer 66⅓ feet, which being multiplied by 16, the square of 4 gives t for the height of the hill. But when the height is given, divide it those square numbers, 4, 9, 16, 25, &c. till the quotient come within of the table, and multiply the quotient by the square root of the hat is, by 2, or 3, or 4, or 5, &c. for the distance sought; so when the Peak of Teneriffe, said to be about 3 miles, or 15,840 feet high, just o view at sea, divide 15,840 by 225 or the square of 15, and the s 70 nearly; to which in the table answers by proportion nearly $10\frac{2}{7}$ en multiply $10\frac{2}{7}$ by 15, gives 154 miles, and $\frac{2}{7}$ for the distance of the

it has been already stated, no regard has been paid to the effect of in elevating the apparent places of objects. But as the operation of incurvating the rays of light proceeding from objects near the hori- nsiderable, it can by no means be neglected, when the difference the true and apparent level is estimated at considerable distances. It ertained, that for horizontal refractions the radius of curvature of the refraction is about 7 times the radius of the earth; in consequence of e distance at which an object can be seen by refraction, is, to the dis- which it could be seen without refraction, nearly as 14 to 13; the augmenting the distance at which an object can be seen by about a h of itself. By reason of this refraction too, it happens that it is neces- liminish by $\frac{1}{7}$ of itself, the height of the apparent above the true level, in the preceding table of reductions. Thus, at 1000 yards. the true e of level, when the allowance is made for the effect of refraction, will be 367=2.203 inches At two miles it would be $32-4\frac{1}{2}=27\frac{3}{7}$ inches,

n.

y simple, portable, and easily constructed instrument for ascertaining the s of distant objects, was inserted in the *Register of Arts;* and as con- ith the foregoing subject, we annex an engraving of it, (p. 82.) A B, B C, d pieces of wood turning on a screw at B; *c d f* a slip of parchment or ted to the legs A B, B C, and folding between them when closed, after ode of a fan. Let the outer part *d f f* be made the quadrant of a

circle to radius e d, and let it be divided into 90 degrees; e j g a plum falling from the centre C h h, two sights. If through h h the top of any



be observed, the plumb-line *e j g* will cut off the number of degrees *j* tained by the angle of elevation. The proof is very evident. Let *h* l *m* horizontal line, to which *e j g* will always fall perpendicular; and since l a right angled triangle, (*Euclid* vi. 8.) $\angle$ *fig.* = $\angle$ *e* l *m* = $\angle$ of elevatio instrument may be closed as N, and carried in the pocket.

LEVELLING STAVES, *or poles*, are those employed in levelling, to carry the marks to be observed, and at the same time to measure the of those marks from the ground. They usually consist of two mahogany 10 feet long, in two parts, that slide upon one another to about $5\frac{1}{10}$ feet, greater convenience of carriage. They are divided into 1000 equal part numbered at every tenth division by 10, 20, 30, &c. up to 1000; and on o the feet and inches are also sometimes marked. A vane slides up and upon each set of these staves, which, by the pressure of springs, will stationary at any part. The vanes are about 10 inches long, and 4 broad; the breadth is first divided into three equal parts, the two extre painted white, the middle space divided again into three equal parts. wh less; the middle one of them is also painted white, and the two othe black; and thus they are suited to all common distances. These vane each a brass wire across a small square hole in the centre which serve t out the height correctly, by coinciding with the horizontal wire of the te of the level.

LEVER. One of the mechanic powers, or elements of machinery. usually defined an inflexible bar, movable round a fixed point of denominated the fulcrum. There are three kinds of levers, distingui the relative positions of the power, weight, and fulcrum. In levers of kind, the weight is applied at one end, the power that is to move it, other, and the fulcrum between them. In *Fig.* 1, on the next page, represents a lever of this kind, W is the weight, P the power, and F the fu

ices F W and F P
urms of the lever.
umple of a lever of
, in which the ful-
: end, the power P
d the weight W be-
e arms of the lever
by the same letters
and F P. The third
as its fulcrum F at
ght W at the other,
between them, as in

between the power
exceedingly simple.
s applied to a straight
:s acting on it per-
he horizon, the pro-
e power bears to the
s the distance of the
: fulcrum is to the
ower from the same
e power and weight
their distances from
general proposition,
able alike to straight
and to forces in any
e thus stated. The
nce acting on a lever
portional to the per-
drawn from the ful-
of direction in which
To render the laws
his useful instrument
sible, we shall con-
nt cases separately.
represents a lever
s at *b*, the power is
the shorter arm *a b*
b c. For if the lever
tion, the power will
c d, and the weight,
hich represent the
ich the bodies move.
res are proportional
the arms, if we mul-
quantities which are
lengths of the arms,
ce equal quantities.
will remain at rest
ents of its arms in
ons are equal, and
as we have shown,
r and weight are in-
onal to the lengths of
se arms are as 1 to 2,
power of 50 lb. will
a resistance of 100 lb.
appear in a lever of
hird kinds. In *Fig.* 6,

Fig. 1.

Fig. 2.

Fig. 3.

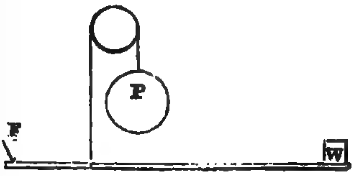


Fig. 4.

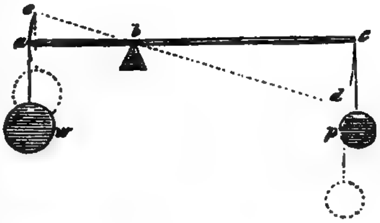


Fig. 5.

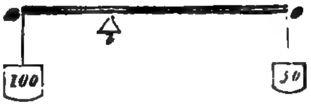
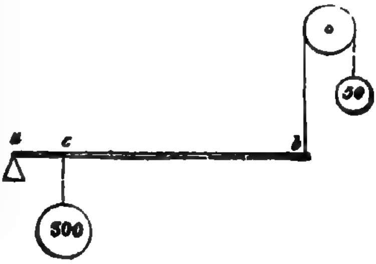


Fig. 6.



towers also formed a considerable part of the fortifications of the early ages and before the invention of making distant signals, the watchmen were furnished with large sea-conchs, which they sounded from the battlements to warn the mariners, or to alarm the country in the case of an enemy. These fire towers, which were once thickly scattered along the shores of the Mediterranean and the Red Seas, became, in time, scenes of the most horrid outrages; thus perverted from their original beneficial uses to the most baneful purposes they were more dreaded than the dangers of the navigation; consequently they fell into disuse and decay, and gradually disappeared.

The most extraordinary of ancient structures of this kind was the Pharos of Alexandria, built on a small island at the mouth of the Nile, whence the word *pharos* has since been considered as synonymous with lighthouse. It was erected by Sostrates with such great magnificence, that it is said to have cost Ptolemy Philadelphius eight hundred talents of gold. It had several stories raised one above another, adorned with columns, ballustrades, and galleries, of the finest marble and workmanship. On the top a fire was kept constantly burning, which, according to Josephus, was seen at the distance of 300 stadia or about 42 English miles. The famous Colossus of Rhodes served also as a pharos. The buildings which have in modern times replaced these ancient structures on the shores of the Mediterranean, &c., are far inferior to those of our own country; and as our limits will not allow of an extended view of the latter, we shall confine our account to the three most remarkable lighthouses of the British and Irish coasts; namely, that on the Eddystone, that on the Bell and that on the South rocks.

The Eddystone lighthouse is situated at the entrance of Plymouth Sound upon an extensive reef of rocks well known to mariners as the Eddy-stone (a name sufficiently significant of its dangers), lying at the distance of 9½ miles from the Ram-head or nearest point of land. The many fatal accidents which happened on these rocks, rendered it very desirable to erect a lighthouse on the spot, but the numerous and apparently insurmountable difficulties of such an undertaking prevented the attempt till the year 1696, when Mr. Winstanley undertook and accomplished this important object, though it was the work of four years. A violent storm, however, in 1703, destroyed every vestige of it except some irons that were fastened in the rock. It was rebuilt in an improved form by John Rudyerd, a linen draper of Ludgate Hill, London. This building was of wood, in form the frustrum of a cone; it was formed of 71 upright beams, united together by being bolted to circular kirbs of wood placed within side, and upon which the floors were framed. Mr. Rudyerd made his building quite plain, without the least projection or ornament on which the water could act when dashing against it. The building was fitted up quite solid for 19 feet from the lowest point of the rock, and, excepting the well for the stair-case, was solid to the height of 37 feet. The solid was formed of three beds of moor stone, with strong floorings of timber between each bed, to unite them with the external uprights. The whole erection, in addition to the weight of this stone (which was about 280 tons,) was secured to the rock by 36 iron cramps. In the centre of the building a strong mast was erected, secured by 2 cramps to the rock at the bottom, and rising above the solid to the height of 48 feet, being united to the framing of each floor it passed through, and thus forming a central axis to strengthen the whole. This building had some repairs of its timbers in 1723, and again in 1744; but it showed itself, during the buffetings of the sea, for 49 years, to be of a very excellent construction. It was destroyed by fire in 1755. In 1756 Mr. Smeaton was employed to rebuild it. From the great uncertainty of the weather, every stone was so contrived that it was of itself in a condition to resist the wash of the sea, even when it was immediately laid. Each stone had one or two holes drilled through it before it left the work yard; and this hole being continued a few inches into the rock, or the stone beneath, a strong tree-nail was driven through it to pin it fast to its place: dovetails were also cut in the edges of each stone to connect them by oaken wedges, which secured the joinings whilst the mortar or cement was hardening; and as a further precaution against the latter being effected by the weather, all the

outsides of them were coated with plaster of Paris. The work went rapidly on in this manner, and the second course was nearly set in a few days; but a gale sprang up, which obliged the operators to quit the work, leaving a few stones of the second course lowered down into their places, and chained strongly to the rock; and one of the most exposed was secured by laying upon it five cwt. of lead. A storm came on, and it was afterwards found that this weight had been lifted by the waves, so that the stone beneath it had escaped and was lost, as were four others; from which circumstance the force of the sea on the rock may be conceived. The light-room was prepared in London; it consisted of eight cast-iron pillars for containing copper sash-frames for eighteen panes of glass each, with a cupola of wrought-iron and copper, terminating with a large gilded ball. The light consisted of twenty-four large tallow candles, suspended in a chandelier, and the first light was exhibted on the 16th of October, 1759, which has been continued ever since without any particular occurrence, or any accident produced by the many violent storms which have happened. In the year 1807 the chandeliers and the candles were removed, and in their place a reflector frame was fitted up with Argand burners and parabolic reflectors of silvered copper, to the great and essential improvement of the light. See *Smeaton's Narrative, &c. of the Eddystone Lighthouse.*

We now proceed to a brief account of the Bell-rock lighthouse, which, like its model, the Eddystone lighthouse, has figured in a thousand periodical publications, and will therefore not require the accompaniment of illustrations in our work. The Bell-rock is a dangerous reef, situated in the Firth of Forth, and the lighthouse upon it is of recent date. Various expedients have been resorted to at different times to warn the mariner of his approach to this rock, which is the more dangerous, as it is 12 feet below the surface at high-water. None of these, however, could be rendered durable; and though the necessity of a lighthouse was acknowledged on all hands, the difficulties and expenses attending such a work prevented the undertaking till the year 1806, when it was finally determined to erect a building of stone similar to that on the Eddystone rock. The work was begun in the year 1807 by erecting a building of timber as a temporary refuge for the workmen, which occupied the whole of the first season, as it was only for two or three hours each tide that the workmen could proceed. The winter was spent in preparing the stones ashore at Arbroath, and in the following summer four courses of stories were completed. In 1809 the solid part of the lighthouse was finished, being about 30 feet high. By September in the next year, the building was raised to its height of 100 feet, and a light was exhibited in February, 1811. The building is a circular tower, measuring 42 feet in diameter at the base, and 13 feet in diameter at the top. The ascent from the rock to the top of the solid, or lowest 30 feet, is accomplished by a trap ladder; but strangers who cannot well ascend by such paths, are hoisted up in a chair by means of a crane. The light-room is 88 feet above the medium level of the tide, yet the sprays of the sea occasionally lash against the glass, so that it becomes necessary in gales of wind to shut the whole of the dead-lights to windward. The light-room is of an octagonal figure, 12 feet across, and 15 feet in height. The light is from oil, with Argand burners placed in the focus of silver-plated reflectors. Machinery is used for tolling two large bells night and day during the continuance of foggy weather. Four light-keepers are appointed, three of whom are always at the lighthouse, and one, in his turn, is ashore at liberty. At Arbroath, a village on the coast about 12 miles distant from the Bell-rock, is a signal tower with an observatory, from which corresponding signals are kept up with the lighthouse.

The most remarkable lighthouse on the Irish coast is the Kilwarlin or South-rock lighthouse, lying off the coast of Downshire, and near the entrance of Loch Strangford, a station of great importance to the navigation of the Irish Channel. This lighthouse stands upon an extensive reef, lying about 3 miles from the shore. Part of the rock is at all times above the perpendicular rise of the tide, but the foundation of the lighthouse is only about 4 or 5 feet above low water of spring tides. It was the work of the late Mr. Rogers, engineer to the Board of Customs: it was founded in 1795, and measures 31 feet diameter at the base, 17 feet diameter at the top, and its height about 70 feet.

LIGHTNING. The explosion of the electric fluid in the atmosphere

LIGHTNING CONDUCTORS, are pointed metallic rods fixed to the upper parts of buildings, to secure them from strokes of lightning. They were invented and proposed by Dr Franklin for this purpose, soon after the identity of electricity and lightning was ascertained; and they exhibit a very important and useful application of modern discoveries in this science. This ingenious philosopher having found that pointed bodies are better fitted for receiving and throwing off the electric fire than such as are terminated by blunt ends or flat surfaces, and that metals are the readiest and best conductors, soon discovered that lightning and electricity resembled each other in this and other distinguishing properties; he therefore recommended a pointed metallic rod to be raised some feet above the highest part of a building, and to be continued down into the ground, or the nearest water. The lightning, should it ever come within a certain distance of this rod or wire, would be attracted by it, and pass through it in preference to any other part of the building, and be conveyed into the earth or water, and there dissipated without doing any damage to the building. Many facts have occurred to prove the utility of this seemingly trifling apparatus. Some electricians have objected to the pointed termination of this conductor, preferring rather a blunt end, on the supposition that a point invites the electricity from the clouds, and attracts it a greater distance than a blunt conductor.

Although the application of lightning conductors to buildings on shore is always judicious, and their advantages very apparent, yet on ship-board, where the effects of lightning are most to be dreaded, the introduction of this means of defence has been slow and imperfect. The conductor hitherto employed at sea consists of long flexible chains or links of metal, about a quarter of an inch thick, sometimes of iron; those employed in the British navy are however of copper; they are usually packed in a box, and are intended to be set up from the mast-head to the sea when occasions require, so that, as observed by Mr. Linger in his excellent work on electricity, partly from inattention, and partly from prejudice, they frequently remain in the ship's hold during long and hazardous voyages quite unemployed; a remark, the truth of which is but too frequently verified in the damage so constantly happening at sea during lightning storms. The necessity of providing the best possible security against the effects of lightning on ship board has long admitted; but continuous and fixed metallic rods have been deemed inapplicable to ships in consequence of their masts (the only parts to which they can be attached) being exposed to chances of injury, to motion in a variety of ways, to frequent elongation and contraction, and to the necessity which frequently arises for removing the higher masts altogether and placing them on deck. It was probably from these causes that the small flexible chains or links above mentioned were employed. Such conductors, however, will probably, on examination, be found less applicable than fixed continuous lines of metal, and, in every point of view, inefficient substitutes for them. Their great want of continuity, as well as their want of mass and surface, is very unfavourable to the transmission of severe explosions, the electric matter becoming sensible at the points of junction, as is evident by the sparks which appear upon them at the time of the discharge, so that in some instances they have been actually disunited; they are likewise objectionable as being liable to every species of injury incident to a ship's rigging, and much difficulty is experienced in keeping them in their position and unbroken, more especially during gales of wind, and at night, when the ship is under sail, and when it is perhaps required, as is already observed, to remove some portion of the higher masts. It has therefore been long considered desirable to apply, if possible, a permanent conductor, which should be always in its place and ready for action; and various attempts have been made and suggestions advanced at different times, to apply fixed lightning conductors in ships, as the subject, from time to time, has demanded further consideration. To protect a ship effectually from damage by lightning, it is essential that the conductor be as continuous and as direct as possible, from the highest point to the sea, that it be permanently fixed in the masts throughout their whole

…wrt, so as to admit of the motion of one portion of the mast upon another; and in case of the removal of any part of the mast, together with the conductor attached to it, either from accident or design, the remaining portion should still be perfect and equivalent to transmit an electrical discharge. To fulfil these conditions, Mr W. J. Harris, of the Plymouth Institution (to whose valuable paper on this subject, contained in a recent number of *Jameson's Edinburgh Journal*, we are indebted to the previous remarks), has recommended pieces of sheet-copper, from one-eighth to one-sixteenth of an inch thick, and about two feet long, and varying from six inches to one inch and a half in breadth, be inserted into the masts in two laminæ, one over the other; the butts or joints of the one being covered by the central portions of the other. The laminæ should be rivetted together at the butts, so as to form a long elastic continuous line: the whole conductor to be inserted under the edges of a neat groove, ploughed longitudinally in the aft side of the different masts, and secured in its position by wrought copper nails, so as to present a fair surface. The metallic line thus constructed will then pass downward from the copper spindle at the mast-head, along the aft sides of the royal mast and top-gallant mast, being connected in its course with the copper about the sheeve holes. A copper lining to the aft side of the cap, through which the top-mast slides, … takes up the connexion, and continues it over the cap to the aft side of the top-mast, and so on as before, to the step of the mast; here it meets a … wide copper lining, turned round the step under the heel of the mast, and … on a similar layer of copper fixed to the keelson. This last is connected with some of the keels on bolts, and with three perpendicular bolts of copper, of two inches diameter, which are driven into the main keel upon three transverse or horizontal bolts, brought into immediate contact with the copper expanded over the bottom. The laminæ of copper are turned over the … mast heads, and secured about an inch or more down on the opposite side; the cap which corresponds is prepared in a somewhat similar way, the copper being continued from the lining in the aft part of the round hole of the cap, into the fore part of the square one, where it is turned down and secured as before, so that when the cap is in its place the contact is complete. In this way we have, under all circumstances, a continuous metallic line from the highest point to the sea, which will transmit the electric matter directly through the keel, being the line of least resistance. But since the main mast … step on the keelson, it will be necessary to have a metallic communication, at the step of the mast, with the perpendicular stancheon immediately under it, and so on to the keelson as before, or otherwise carry the conductor … the sides of the vessel.

From what has been already observed, it will be apparent that in whatever position we suppose the sliding masts to be placed, whether in a state of elongation or contraction, still the line of conduction will remain perfect; for that part of the conductor which necessarily remains below the cap and top when the sliding masts are struck, is no longer in the line of action; consequently its influence need not be considered.

LIME. One of the primitive earths; and since the discovery by Sir H. Davy of its metallic base, which he denominated *calcium*, it is regarded by chemists as the *oxide of calcium*; that important substance commonly called lime being found to be a combination of calcium and oxygen. The nature of lime is proved by the phenomena of the combustion of calcium; the metal changing into the earth with the absorption of the oxygen gas. Lime is soluble in 450 parts of water, according to Sir H. Davy, and in 760 parts according to other chemists. The solution is called *lime water*, which is limpid, but has an acrid taste, and turns vegetable blues to green. If lime water be allowed to stand, a film called the *cream of lime* forms on its surface; and if this be removed as it forms, till by this means the whole of the lime may be separated from the water. If the lime be not skimmed, the cream, after having acquired a certain thickness, precipitates and falls to the bottom. Pure lime, or calcareous earth, is never found native; but in combination with acids, particularly the carbonic, it exists in prodigious quantities. Marble, limestone, and chalk, are

all carbonates of lime; gypsum is a sulphate of lime. Berzelius attempted to determine the prime equivalent of calcium, from the proportion in which it combines with oxygen to form lime: on which Dr. Ure remarks that "his results can be regarded only as approximations, in consequence of the difficulties of the experiment. The prime equivalent of lime, or oxide of calcium, can be determined to rigid precision by my instrument for analyzing the carbonates. By this means I find that 100 parts of carbonate of lime consist of 43.60 of carbonic acid + 56.4 lime; whence the prime equivalent proportions are 2.75 acid + 3.562 base."

The operation called burning lime, consists in exposing marble, limestone, chalk, oyster shells, or any other carbonate of lime, for some time to a white heat, by which means the carbonic acid and water contained in these substances are expelled; and the earth which has the peculiar characters assigned to lime, is left behind in a mass which has little coherence, and is therefore easily reduced to powder. It is usually called quick-lime after calcination. Newly prepared it absorbs water with great avidity; it will absorb one-fourth of its weight of that fluid, and still remain perfectly dry. If a sufficient quantity of water be poured upon it, the lime falls into powder; some of the water is converted into vapour by the disengaged caloric of that part which unites with the lime; this is called the slacking of lime: if the quantity slacked be considerable, and performed in a dark place, light will be observed as well as heat.

The kilns for burning lime are of a great variety of forms, according to the kind of fuel used, and the manner in which they are to be wrought. Some persons affirm that the best form of a lime-kiln is that of an egg placed upon its narrow end, having part of its broader end struck off, and its sides somewhat compressed towards the lower extremity; the ground plate, or bottom of the kiln, being nearly an oval, with an eye or draft hole towards each end of it. It is supposed that two advantages are gained by this form over that of the spreading inverted cone (also much used). By the upper part of the kiln being contracted, the heat does not fly off so freely as it does in the spreading cone; on the contrary, it thereby receives a degree of reverberation which adds to its intensity. But the other, and more valuable effect is said to be this; when the cooled lime is drawn out at the bottom of the furnace, the ignited mass in the upper parts of it settles down freely and evenly into the central parts of the kiln. One of the best kilns that we are acquainted with is Heathorn's patent kiln, combined with the manufacture of coke, and described under the article IRON. The frustrum of a cone is a form of kiln much used; and it may be some advantage to hollow or arch out the upper part, which is frequently done. In many parts of the south of England, lime is prepared from the calcination of chalk in kilns sunk in the earth, of the form of inverted cones, and lined with brick; the base of the cone is about 10 feet in diameter, and about 14 feet deep. It is calculated that a kiln of this kind will yield 150 bushels of lime in 24 hours. When the chalk is dry, about 5 bushels of it may be burned with 1 bushel of coal; but when damp, or in the winter, not more than 4 bushels by 1 bushel of coal. In Yorkshire, and some other places where coal is abundant, calcareous slate and limestone are burned in great pieces stratified with coal: in these cases the consumption of coal is equal to more than a third part of the lime produced. The waste of fuel in this process renders it very ineligible where coals are dear. The saving of fuel in the use of kilns is apparent from the previous accounts, but that saving, according to Mr. Rawson, may be considerably increased by inclosing the kiln at the top, and building a chimney over it; and it seems to follow that the higher that chimney is the better.

Some lime-burners prefer peat to coal for the fuel; but that preference has probably arisen from an injudicious management of coal. Mr. Dodson asserts peat to be more economical than coal; that coal, by its excessive heat, causes the limestone to run into solid lumps, which it never does with peat, as it keeps them in an open state and admits the air freely. That the process of burning goes on more slowly with coal, and does not produce half the quantity of lime. This inconsistency requires no comment; nevertheless peat is a very useful fuel for the purpose, and an excellent substitute for coal where the latter is scarce:

or dearer. All kinds of lime exposed to the air recover nearly their original weight, except chalk lime, which, although long exposed, never recovers more than seven-eighths of its original weight. Some limestones, as Portland-stone, yield a very white lime; others, as chalk and roe-stone, a lime with a yellowish cast; the latter is best adapted for mixing with tarras, puzzolano, or Parker's cement, for buildings under water. It has long been said by lime-burners, that if limestone be imperfectly burned in the first instance, no further exposure of it to the fire will produce quick-lime. This assertion, which it was supposed was the offspring of ignorance, has been confirmed by M. Vicat, in a valuable treatise lately published by him on mortar and cements. Such lime, which is technically termed dead lime, does not slake with water, but upon being ground and made into a paste with water, differs from common mortar by setting under water.

Whiting is a fine carbonate of lime, made in some places by grinding soft chalk in a mill, separating the finer particles by washing them over in water, letting the water settle, and making up the sediment into loaves, which are exposed to the air to dry. There are numerous manufactories beside the river Thames, where whiting is thus prepared, the loaves being exposed on shelves in lofty sheds, which form, as it were, the vertical external walls of the buildings. In some places whiting is made from lime by slaking it with a little water, then grinding it in a mill with water, exposing the lime water to the air for some time to absorb the carbonic acid from the atmosphere, washing over the sediment, making it into loaves, and drying them. When made into small loaves it is called *Spanish white*; and if in small drops, *prepared chalk*; the *creta preparata* of the apothecaries. It is principally used as a white paint, either alone, or mixed with white lead; the inferior priced white lead has a large proportion of whiting mixed with it. Spanish white and prepared chalk are likewise extensively used to saturate acids in liquids in various chemical and manufacturing operations.

Lime with water form a paste of but little cohesion; for common mortar is mixed with rough sand to give it firmness; but the mortar for the outermost covering of in-door work, is mixed with hair to give it cohesion without lessening its capability of receiving a smooth surface. As lime absorbs carbonic acid gas as well as water from the atmosphere, it should be made into mortar before it has imbibed any considerable portion of it, otherwise it will be of little value. It is by the absorption of carbonic acid that mortar acquires hardness, its lime being slowly converted again into the state of limestone; but the hardness will not be perfect unless undisturbed from its commencement; when this circumstance is observed it soon acquires a moderate degree of hardness, but ages are probably required for it to attain its maximum. The silex or sand mixed with lime operates by hastening its crystallization. Lime, though infusible alone, promotes the fusion of all the other earths, and is extensively used in smelting iron ores; it serves as a flux to the alumine and silex which the ores of that metal contain.

Marl, which is of so much value in agriculture, consists of a mixture of lime and clay, and it is the calcareous part of its composition to which its value is owing; if the quantity of lime in it do not exceed 30 per cent. it is worthless. Every good soil contains a portion of carbonate of lime, which materially assists in retaining the moisture necessary to active vegetation. Limestone containing much magnesia is unfit to afford lime for the farmer's use; it may be known from good limestone by its being much longer in dissolving in acids. Lime is used by the soap manufacturer to render his soda caustic: it enters into the composition of glass, which it renders less liable to attract moisture, and less brittle than it would otherwise be. It is employed in the manufacture of glue to prevent its becoming flexible by the ready absorption of moisture. It is used by the tanner to facilitate the removal of the hair from skins. It is used by the sugar refiner to absorb the acid, which would prevent the sugar from crystallizing. A solution of lime is employed to cleanse feathers from their animal oil, and render them sweet and fit for use. Acids dissolve pure lime with effervescence, but heat is evolved during the solution. Water impregnated

with carbonic acid will dissolve a much larger quantity of it than before; and when deprived of this acid by exposure to the air, the lime it held in solution is precipitated; hence the formation of stalactites and incrustations found in caverns. The crystals of the solutions of lime in acids form what are called spars. The beautiful spar called fluor spar, or Derbyshire spar, is a fluate of lime, that is, a combination of lime and the fluoric acid. Combined with muriatic acid, large quantities of lime are held in solution by the waters of the ocean. Combined with sulphuric acid lime forms gypsum; gypsum, when calcined by a moderate heat, is called plaster of Paris. Combined with the oxymuriatic acid, or chlorine, it forms chloride of lime, the famous salt used in BLEACHING, (which see.) Combined with phosphoric acid, lime forms the solid parts of the bones of all animals. The shells of testaceous animals consist chiefly of carbonate of lime cemented by a small portion of animal glue; while those of crustaceous animals always contain more or less of phosphate of lime, which approximates them to the nature of bone.

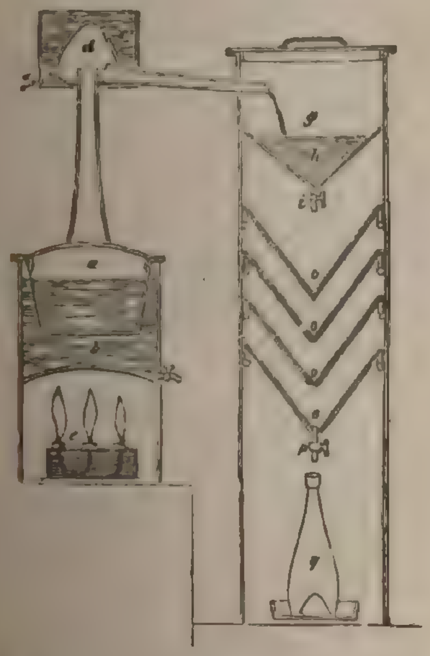
LIMESTONE. The native indurated carbonate of lime is usually distinguished by this name; but Professor Jamieson considers it as a genus of minerals, which he divides into four species; namely, Rhomb-spar, Dolomite, Limestone, and Arragonite; the third species, limestone, he divides into twelve sub-species, and these again into several kinds.

LIMNING. The art of painting in water colours, as practised by the ancients, in contradistinction to the more modern art of painting in oil. Before John Van Eyck (better known by the name of John of Bruges) found out the art of painting in oil, the painters all painted in water or fresco, on their walls, on wooden boards, and elsewhere. When they made use of boards, they usually glued a fine linen cloth over them, to prevent their opening; then laid on a ground of white; lastly, they mixed up their colours with water and size, or with water and yolks of eggs, well beaten with the branches of a fig-tree, the juice whereof thus mixed with the eggs; and with this mixture they painted their pictures. In limning, all pigments are suitable, except the white of lime, which is only used in fresco. The azure or ultramarine is always mixed with size or gum; and two layers of hot size are always applied to the boards, before the size colours are laid on; the colours are all ground in water, and in working diluted with size water. When the piece is finished, they go over it with the white of an egg well beaten; and then with varnish, if required.

LINT. The scrapings from the surface of old linen cloth, forming a very soft absorbent material, peculiarly adapted to the dressing of wounds; for which purpose it is chiefly used. This material is prepared for the use of surgeons, and as an article of commerce, in the following manner. Old linen, or such as has been worn for shirts, sheets, &c. is preferred to new cloth, on account of the great softness of the fibrous matter. Those pieces are selected which are without fracture, or nearly so, and that are 10 or 12 inches broad; these are washed, (or should be,) perfectly clean, and dried, and are then ready to be operated upon by the lint machine, which is generally worked by a woman. This machine consists of a steel knife blade with parallel sides, the edge of which is blunt or dull, but perfectly straight; this knife is fixed in a horizontal position in a frame, which is made to reciprocate up and down, by means of a treadle or pedal. When this pedal is pressed upon by the foot of the workwoman, it causes the blade to descend vertically with its edge across a board or little table, covered with smooth leather, whereon the linen is placed; and on taking the pressure off the pedal, the knife is lifted from the work by the agency of springs. The linen is rolled *very evenly* upon a cylindrical stick, with the weft in the direction of the stick; and consequently with the warp threads of the cloth rolled round it. A few inches of the cloth being uncoiled, and a few threads of the weft pulled off at the end, leaving as it were a fringe of the warp projecting, the roller is held steadily with both hands by the operator, who begins by placing the end of the cloth in such a position upon the work board, that when, by the pressure of the foot upon the pedal, the knife descends, its edge shall pass between the first and second thread of the weft, and press across all the warp threads; whilst the latter is thus held down to the table,

the operator pulls back the stick towards her, through a space of from a quarter to half an inch; the weft thread is thereby pushed further along the warp threads, and from the latter is scraped the lint, by their being drawn under the edge of the knife. The foot being lifted from the pedal, the knife ascends, and the operator pushes the cloth forward again to take the next thread, which, by the pressure of the knife, and the pulling back of the cloth at the same instant, is moved along the threads of the warp after the first, and raising thereby more lint. In this manner the operation is conducted, thread after thread, (almost as quickly as a person could count them,) until all the cloth (or all the pieces of cloth sewn evenly together) upon the cylindrical stick is worked off; and then is produced, when the work is dexterously performed, a continuous tender sheet of thick downy lint. Simple as this operation may appear, it requires considerable practice to obtain the necessary skill and adroitness to do the work well, and enable the operator to get a living by it; it is usually executed by very poor women, who earn only about ten shillings per week at the employment. The difficulty consists in making accurate movements by the hands with great quickness; for if a weft thread is crossed by the knife, the work is checked or spoiled instead of forwarded. The editor has never met with any published description of this operation, but he saw it performed about 20 years ago by a poor old woman, and this account is sketched out from recollection.

LIQUEURS. This name, adopted from the French, is given to a variety of odoriferous, fine flavoured, alcoholic liquors; the processes of preparing which have been given in various parts of this work; see EAU DE COLOGNE, EAU DE LUCE, &c. In this place we shall insert the description of a very convenient little



apparatus, and the process of working it, which we understand is much used in Paris, and elsewhere, for the purpose. At *a* is the boiler (containing the diluted spirits and flavouring ingredients) immersed in a water bath *b*, and heated

by a spirit lamp *c*, having several wicks. The still has a tall neck, sur by a head *d*, surrounded by cold water in the refrigeratory *e*. The va it is condensed, runs down the sides of the head, and is received in a channel, formed around the upper extremity of the neck, whence it flo a pipe *f*, through the cold water cistern, into a recipient *g*, fixed above of funnel-shaped filterers. Previous to commencing the process of dist the recipient *g* is provided with a sufficient quantity of syrup, (solution sugar,) to form the intended liqueur, over which the condensed spirit di itself. When all the spirit is come over, the distillation is stopped b guishing the lamp; the cock *i* is now opened, when the aromatic spirit syrup descend into the first of the filterers *o o o o*. These filterers are c posed of four distinct substances or layers; the lowest is of perforated the next above fine flannel, over which is put two thicknesses of filterin The spirit and the syrup become intimately blended in passing throu successive filterers, and the liquor is received in bottles underneath fectly bright and clear state.

LITHIA. An alkali, recently discovered by M. Arfredson, a young employed in the laboratory of M. Berzelius. Sir H. Davy demonst voltaic electricity that the basis of this alkali is a metal, to which the *lithium* has been given. For the mode of obtaining lithia, and an acc its properties, the reader is referred to *Ure's Dictionary of Chemistry*, not yet been brought into use in the arts.

LITHOGRAPHY. The art of transferring from stone, writings or d made thereon; which is quite of modern invention. Unlike other printing, this is strictly chemical, and is in consequence called in G *chemical printing*. A drawing is made on the stone, either with ink co oleaginous matter; or with chalk, containing similar substances, but in concentrated and indurated state. The drawing is then washed over wit which sinks into those portions of the stone that are untouched with th of the drawing. A cylindrical roller, charged with printing ink, is then all over the stone, and while the drawing receives the ink, the rest of t is preserved from it by the water on account of the greasy nature of This art is said to have been invented by mere accident, by Alois Senef Munich, who being an author, and too poor to publish his works, tried plans, with copper-plates and compositions, with a view to becoming printer. In the course of his experiments, he found that a composition wax, and lamp-black, formed an excellent ink for writing with on pl when dry, it became firm and hard, and resisted aquafortis. He wanted however, in writing backwards on the plates; and that he might exercis less expense, he procured some pieces of Kilheim stone, as a cheap ma which, after polishing their surfaces he might practise. Having been de his mother to take a list of some linen about to be sent to be wash having no paper at hand, he wrote it out on a piece of stone with his c tion. When he was afterwards about to efface his writing, it occurred that impressions might be obtained from it; and after he had bit in t with aquafortis, diluted with ten parts of water, after letting the fluid s minutes over it, he proceeded to apply printing ink to the stone, for wh pose he first applied a printer's ball, but after some unsuccessful trials, use of a thin piece of wood covered with fine cloth, and with this he succeeded in taking impressions. It appeared to him that this new printing was of very considerable importance; and he therefore, thou great difficulties, persevered in improving it, and in attempting its ap to practical purposes. He soon found that it was not necessary to letters raised above the stone; but that the chemical properties wh grease and water so effectually separate from each other, were quite for his purpose. He afterwards bestowed much labour and assiduity structing the proper press, and other apparatus for printing. The firs to print for publication were some pieces of music executed in 1796; af he attempted drawings and writings. He still however found great in writing backwards, and this led him to think of the process of tran

use of dry soap, which was found to leave permament traces which would impressions, naturally led to the mode of chalk drawings. In 1799, after ing made many improvements, Senefelder obtained a patent privilege for lectorate of Bavaria. In 1803, he introduced his discovery into Vienna, re he obtained a similar grant for ten years. The invention spread, though into France and Italy, but it was not brought over to England until when M. André d'Offenbach, a merchant in London, succeeded in introng it only to a very limited extent. While the war lasted, the employment he lithographic art was chiefly confined to the quarter-master general's at the Horse Guards, where it was used for printing the plans of s, and maps of the seat of war. After the peace the art was revived, and are now in England, as well as in all parts of the continent, numerous lishments, where it is practised with great excellence; and it is difficult to at the present time, whether the German, French, or English artists, have ned the pre-eminence. We shall now proceed to explain the several pro of the art.

he Stones, and the manner in which they are prepared to receive the drawings.—stone most used in England is found at Corstan, near Bath: it is one of white lias beds, but not of so fine a grain, nor so close in texture as the man stone, and therefore inferior; but it is good for transfers, and does ably well for ink drawings or writings. All calcareous stones may be used hography, because they imbibe grease and moisture; but a stone entirely reous does not answer well; there should be a mixture of alumina and One of the most certain indications of lithographic properties, is the oidal fracture: all stones of this kind will be found good, if they are also have the fineness of grain, and the homogenousness of texture that are sary. It is however *said* that none have yet been found equal to those ned from the quarries of Solenhofen, near Pappenheim in Bavaria, and the lithographers of eminence in Paris use no other. In order to sustain pressure used in taking impressions, a stone, 12 inches square, ought not to be than 1½ inch thick, and this thickness should increase with the area of ne. The stones are first sawn to a proper size, and are then ground and level by rubbing two of them face to face, with water and They must be very carefully examined with a straight edge, to ascertain they are perfectly level in every direction. This applies only to the side is afterwards to receive the drawing, as the natural division of the stone is ently true for the back. When the stones have thus been ground perfectly they are well washed, to free them from any of the courser grains of sand may have been used in smoothing them. They are then placed on a over a trough, and they are again rubbed face to face with sand and , but with a sand of much finer texture than that previously used. The st care must be taken to have the sand sufficiently fine; and for this pur it must be sifted through a small close sieve, as a single grain of sand of a r texture than the rest will scratch the stone, and these scratches will wards appear in the impression taken from the stone. When the stones been rendered sufficiently fine, and their grain sufficiently smooth, they then be carefully washed and afterwards wiped dry with a clean soft cloth. is the plan adopted to prepare the stones for chalk drawings, but to pre them for ink drawings or writings, the following method is the best:—After process just described has been completed, the stones are well washed to get the sand, and they are then rubbed to together, face to face, with pow pumicestone and water. After they are made perfectly smooth, they are washed and wiped dry, and are then separately polished with a large piece umicestone.

clean the stones after they have been fully used, sand is strewed over the e, which is sprinkled with water and rubbed with another stone, until the g or drawing upon it has completely disappeared. It must then be washed aquafortis, diluted with twenty times its bulk of water; and the stone is then red for a new drawing or writing, by being rubbed with fine sand or cestone as before. The longer drawings remain on stones the deeper the

ink or the chalk penetrates into their substance, and consequently the m the stone must be ground away to remove them; this is also more nec with ink drawings or writings than with chalk, owing to the greater fl and consequent penetrability of the former.

The substances used by the artist upon the stone, are either lithographi or lithographic chalk. The former has been described under the artic (which see,) but—

The Ink for making transfers should be somewhat less burned, and the softer than that used for writing or drawing directly upon the stone.

Lithographic chalk should have all the qualities of a good drawing cr It should be even in texture, and carry a good point. The following pr tions are recommended: 1½ oz. of common soap, 2 oz. tallow, 2¼ oz. virgin 1 oz. shell-lac. The rest of the process is the same as in making the Less black should be mixed with the chalk than with the ink, its only use be colour the drawing, that the artist may see the lines he traces. When the is well mixed, it should be poured into a mould and very strongly press expel any air that may collect in bubbles, which would render it spongy.

Mode of drawing.—Previous to drawing or writing, the stone must be wiped with a clean, dry cloth. The ink is rubbed with water, like Indian and is almost wholly used on the polished stone. The chalk is used only the grained stone; the polished surface of the other would not hold it. drawing with ink, a gradation of tints is obtained either by varying the ness of the lines, or their distances from one another, as in engraving. ink lines on polished stones, being solid and unbroken throughout, receiv printing all over; and if the lines be drawn as fine and as uniform as the usually on copper, the print from them will be in no respect inferior; b requires a greater degree of skill to execute as well upon stone as is u done upon copper or steel.

In using chalk, the grained stone should be very carefully dusted, and utmost attention be paid to prevent any lodgment of the smallest partic grease upon the surface; personal cleanliness is therefore absolutely nece to the perfection of his work, especially in chalk drawings. The chalk is upon the stone precisely in the same manner as crayon upon paper; but of essential advantage in lithography to finish the required strength of *at once*, instead of going over the work a second time, the stone being imp in its ability to receive the second lining clearly, by the absorption of first. Some practice is requisite to use the chalk cleverly, as there has no chalk hitherto made that will keep so good a point as is desirable. T is likewise some difficulty experienced in obtaining the finer tints sound in impression; and in order to obtain the lighter tints properly, it will be nece to put the chalk in a rest, as the metal port crayon is too heavy to draw the stone. The editor, who sometimes practises, is in the habit, before he c mences his subject, of pointing 20 or 30 pieces of chalk, stuck in quill hol and placing them beside the stone in a little box, taking them up success as the points become worn off, so as to avoid, if possible, the cutting off during the work, which endangers the soiling of the stone. When a very and delicate line is required, he sharpens the point of the chalk upon pape pushing it forward in an inclined position, and twirling it round at the s time between the fore-finger and thumb. As the chalk softens by the wa of the hand, it is quite necessary to have several pieces, to be able to ch them. Some artists cut their chalk into the wedge form, as being stro Those portions that break off in drawing should be carefully taken off the by a camel's hair brush.

Preparation of the stone for printing.—The drawing being finished on stone, it is sent to the lithographic printer, on whose knowledge of his depends the success of the impressions. The first process is to *etch* the d ing as it is called. This is done by placing the stone obliquely on one over a trough, and pouring over it very dilute nitric acid. It is poured o upper part of the stone, and runs down all over the surface. The stone is turned, and placed on the opposite edge, and the etching water being coll

is again poured over it, in the same manner. The degree of is usually about one per cent. of acid, should be such as to pro- at effervescence; and it is desirable to pass the etching water over the darkest parts of the drawing, as they require more lighter tints. Experience alone can, however, guide the litho- department of the art, as different stones, and different compo- will be differently acted upon by the acid; and chalk drawings acid than the ink. The stone is next to be carefully washed, rain water over it, and afterwards with gum water; and when roller charged with printing ink is rolled over it in both direc- and from top to bottom—till the drawing takes the ink. It is red over with a solution of gum Arabic in water, of about the l. This is allowed to dry, and preserves the drawing from any lines cannot spread, in consequence of the pores of the stone the gum. After the etching, it is *desirable* to leave the stone for more than a week, before it is printed from. The effect of the to take away the alkali mixed with the chalk or ink, which drawing liable to be affected by the water; and secondly, to refuse more decidedly to take any grease. The gum assists in se, and is quite essential to the perfect preparation of the sur-

hen the intention is to print from the stone, it is placed upon ed of the press, and a proper sized scraper is adjusted to the one. Rain water is then sprinkled over the gum on the stone, solved gradually, and a wet sponge passed lightly over all. the e ink, which is on the colour table placed beside him, with the ections, until it is equally and thinly spread on the roller. The ssed over the whole stone, care being taken that the whole draw- ue portion of ink; and this must be done, by giving the roller n and pressure, which will of course require to be increased, if es not receive the ink readily. When the drawing is first used, ive the ink so readily as it will afterwards; and it is frequently the stone, and roll it several times, before it will take the ink this takes place, care must be taken not to wet the stone too pness should not be more than is necessary to prevent the ink stone where there is no drawing. After the drawing is thus heet of paper is placed on the stone, and the impression taken. e paper off the stone, the latter appears to be quite dry, owing aving absorbed the moisture on the surface; it must therefore be ponge, and again rolled with ink, the roller having been well colour table before being applied. During the printing, some ays remain on the stone, although it will not be visible, other- ill be received on the stone as well as on the drawing, by which uld be spoiled; so that if by too much wetting, or by rubbing the sponge, the gum is entirely removed, some fresh gum water . If the stone has in the first instance been laid by with too y of gum, and the ink stains the stone on being first applied to must be used to damp the stone, instead of pure water. Some- , this may arise from the printing ink being too thin, as will ear. If some spots on the stone take the printing ink, notwith- bove precautions, some strong acid must be applied to them and after this is washed off, a little gum water is dropped in eel point is here frequently necessary to take off the spots of ink. e stone are very apt to get soiled, and generally require to be old sponge after rolling in; they must also frequently have of acid and gum, and sometimes must be rubbed with pumice- k is too thin, and formed of a varnish not sufficiently burned, tone notwithstanding the proper precautions are taken of wet nd preparing it properly with acid and gum; and if, on the other too thick, it will tear the lighter tints of the chalk from the

stone, and thus destroy the drawing. The consideration of these circu leads at once to the—

Principles of the Printing.—The accidents just mentioned arise at the points of the scale at which the printing inks can be used, for it is that the only inks that can be used are those which are between the that is, thicker than that which soils the stone, and, at the same time, than that which takes up the drawing. Lithographers are sometimes to print in very hot weather, the reason of which may be deduced foregoing. Any increase of temperature will diminish the consistency printing ink; the stone will therefore soil with an ink which could used at a lower temperature; hence a stiffer ink must be used. No temperature should increase so much that the stone will soil with any less thick than that which will take up the drawing, it is evident that ing must cease till a cooler temperature can be obtained; for as the chalk is effected equally with the printing ink, the same ink will tea drawing at the different degrees of temperature. This, though it occurs, is a rare case; but it shows that it is desirable to draw with a ink of less fatness in summer than in winter; and also, that if the room is in winter artificially heated, pains should be taken to regulate as equally as possible.

Other Difficulties in Printing, not referable to the foregoing general Pri If the pressure of the scraper be too weak, the ink will not be given paper in the impression, although the drawing has been properly charg it. Defects will also appear from the scraper being notched, or not adjusted, or from any unevenness in the leather or paper. After p considerable number of impressions, it sometimes happens that the takes the ink in dark spots in different parts. This arises from the ink becoming too strongly united with the chalk or ink of the drawing the printing be continued, the drawing will be spoiled. The reason easily ascertained. The printing ink readily unites with the draw being of a thinner consistency, it will, by repeated applications, accum the lines of the drawing, soften them, and make them spread. In th is necessary to stop the printing, and let the stone rest for a day or two drawing to recover its proper degree of hardness. If the drawing sho smutty from any of the causes before enumerated, the following—

Mixture for cleaning the Drawing while printing must be used.—T parts of water, spirits of turpentine, and oil of olives, and shake th together in a glass phial, until the mixture froths; wet the stone, an this froth upon it, and rub it gently with a soft sponge. The pri will be dissolved, and the whole drawing will also disappear, though, examination, it can be distinguished in faint white lines. On again with printing ink, the drawing will gradually re-appear, as at first.

Bleached Paper unfit for Lithographic Printing.—Accidents someti in the printing from the qualities of the paper. If the paper h made from rags which have been bleached with oxy-muriatic acid, t ing will be incurably spoiled after thirty impressions. Chinese paper h times a strong taste of alum; this is so fatal, as sometimes to spoil the after the first impression. When the stone is to be laid by after pr order that it may be used again at a future period, the drawing should in with a—

Preserving Ink; as the printing inks would, when dry, become that the drawings would not take fresh printing ink freely. The is the composition of the printing ink:—Two parts of thick v linseed oil, four parts of tallow, one part of Venetian turpentine, part of wax. These must be melted together, then four parts of la very carefully and gradually mixed with it, and it must be preserve in a close tin box.

Autographic Ink, or that which is suitable for transferring o stone the writings or drawings which have been executed on paper

furnished at a quarter of their present actual value; in fact, all those which are done in lines, or those in which the shadows are boldly executed, are capable of re-producing good impressions by means of autography. The operation becomes extremely difficult when it is necessary to transfer fine line engravings; the lines of these are so delicate, and so near to each other, that they either do not take well on the stone, or are apt to be crushed and confounded together by the effect of the pressure. Much practice and address are necessary to obtain tolerable impressions; and this part of the art requires improvement. In the office of M. de Lasteyrie, they had succeeded in transferring to stone a small highly-finished engraving, which had been printed on common half-sized paper. After having dry-polished a stone very perfectly, it was warmed, rubbed with spirits of turpentine, and then the engraving was applied to it. This had, however, been previously dipped into water, then covered on the reverse side with turpentine, passed again through the water, so as to remove the superfluous turpentine, and then wiped with unsized paper. In this state the engraving, still damp with the turpentine, was applied to the stone and submitted to pressure, when it afforded very good impressions; the *preparation* not being applied until it had remained on the stone for twenty-four hours. The difficulties increase, of course, in proportion to the size of the engravings which it is desired to transfer to the stone. Attempts have been made to transfer old engravings; they have, however, succeeded but imperfectly. It would be rendering an essential service to the art to discover a mode of re-producing old engravings by means of autography; the undertaking presents difficulties, but from the attempts made, success does not seem improbable.

Printing from two or more Stones with different Coloured Inks.—This is managed by preparing a composition of two parts of wax, one of soap, and a little vermilion. Melt them in a saucepan, and cast them into sticks; this must be rubbed up with a little water to the thickness of cream, and applied to the surface of a polished stone. An impression is taken in the common way from a drawing, and applied to a stone prepared in this manner, and passed through the press, taking care to mark, by means of this impression, two points in the margin corresponding on each of the stones. The artist, having thus on the second stone an impression from the first drawing to guide him, scrapes away the parts which he wishes to remain white on the finished impression. The stone must now be etched with acid stronger than the common etching water, having one part of acid and twenty of water; the whole is then washed off with turpentine: this plan is generally used in printing a middle tint from the second stone; the black impression being given from the first stone, a flat transparent brownish tint is given from the second, and the white lights are where the paper is left untouched. The dots are necessary to regulate the placing of the paper on the corresponding parts of the two stones.

LITMUS. See Archil.

LIXIVIATION is the application of water to the fixed residue of bodies, for the purpose of extracting the saline part.

LOCK. A secret fastening for doors and similar things, provided with an arrangement of mechanism designed to prevent the introduction or successful operation of any instrument but that which has been made to fit it, called the key: there is consequently a numerous variety of kinds, qualities, and sizes. A good lock has justly been regarded as the masterpiece of smithery. Locks are of great antiquity; according to M. Denon, they were known in Egypt more than 4000 years ago, which he inferred from some sculptures on the great temple at Karnac, representing locks similar to those now used in that country. It would be difficult to trace the earliest introduction of locks into this country; but there is much evidence showing that very curious and secure locks were made many centuries ago. It appears, also, from the celebrated MSS. of "the famous earl of Glamorgan," entitled "*A Century of the Names and Scantlings of such Inventions,*" &c. as he could "call to mind to have tried and perfected," (his notes being lost,) that the art of lock-making was then by no means in its infancy, as he refers to things as if they were then well known which we now regard as important securities to locks; and some of them are commonly

considered as being of recent invention. For these reasons we think it will not be amiss to introduce in this place some of the "scantlings" alluded to. Making some allowance for the quackery of the noble boaster, the reader, who is acquainted with the construction of our modern locks, will recognise much that is now in use to produce similar effects.

"69. A way how a little triangle-screwed key, not weighing a shilling, shall be capable and strong enough to bolt and unbolt round about a great chest, an hundred bolts, through fifty staples, two in each, with a direct contrary motion, and as many more from both sides and ends; and, at the self-same time, shall fasten it to the place beyond a man's natural strength to take it away; and in one and the same turn, both locketh and openeth it."

"70. A key with a rose-turning pipe and two roses pierced through endwise the bit thereof, with several handsomely-contrived wards, which may likewise do the same effects."

"71. A key perfectly square, with a screw turning within it, and more contrived than any of the rest, and no heavier than the triangle-screwed key, and doth the same effects."

"72. An escutcheon to be placed before any of these locks with these properties. First, the owner, though a woman, may, with her delicate hand, vary the ways of coming to open the lock ten millions of times beyond the knowledge of the smith that made it, or of me who invented it. Second, if a stranger open it, it setteth an alarum a-going, which the stranger cannot stop from running out; and besides, though none should be within hearing, yet it catcheth his hand as a trap doth a fox; and though far from maiming him, yet it leaveth such a mark behind it as will discover him if suspected; the escutcheon or lock plainly showing what money he hath taken out of the box to a farthing, and how many times opened since the owner had been at it."

"The means of giving security to locks," Mr. Ainger observes, "are of two kinds. The first consists in numerous obstacles (commonly called *wards*) to the passage of the key, which requires, therefore, a peculiar form to evade them. The second consists in a number of impediments to the motion of the *bolt;* those impediments being so contrived that their absolute and relative positions must be changed before the bolt can be withdrawn." To these two Mr. Ainger might have added the "*rose-turning pipe*," and the "*secret escutcheon*" from the foregoing "scantlings," which also constitute impediments to many *modern locks*. Means of the first class are defective, because a surreptitious instrument need not thread the mazes of the wards; it escapes them by taking a path outside of them to the bolt, which is unavoidably left for the passage of the extremity of the key. Complexity in the form of the wards, therefore, affords no absolute security against the determined initiated picker of locks, as he can take an impression of the position of the wards, and make an instrument (or skeleton) that will avoid most of them, and take the most direct path to the bolt or its guards. The guards or impediments to the motion of the bolt are called tumblers. A tumbler usually consists of a small lever, one end of which has a little projection, which latches into a notch cut into the bolt, and is kept down by a spring. It is therefore the business of the key, after it has passed the wards, to raise this tumbler out of the notch entirely before the bolt can be moved; the latter motion being effected by the further motion of the key against a curved portion of the bolt. Great exactness in the length of the bit of the key is therefore necessary to make these parts act properly. If the key be too long, it cannot enter the curved portion, and the tumbler is not reached; and if it be too short, by only the thickness of a sheet of writing paper, the tumbler cannot thereby be lifted *quite* out of the notch, and the bolt is, in consequence, immovable. Sometimes the key has a step or notch which acts upon the tumbler, whilst the other portion of the end of the key acts upon the bolt, which adds to the difficulty of false keys. A single tumbler, therefore, confers a certain degree of security, and they are usually applied to locks of a common quality. But as this addition to a lock increases the cost about sixpence, the commonest or cheapest locks have no tumbler, the bolt being held in the position in which the key puts it by the pressure of a spring. Locks

are, however, made, not only without tumblers, but even without wards, fo very common purposes; and being sufficiently secure for their objects, an extremely cheap, they are manufactured in immense quantities, chiefly a Wolverhampton.

In 1774 a great improvement in the art of lock-making in this country wa made by Barron, who took out a patent for it; it consisted in the employmen of two or more tumblers, of the same construction as the single one befor described, but so arranged that they must be operated upon at different time or altogether, and be moved through different spaces, so as to take them com pletely out of their notches, and set the bolt free to be acted upon. The prope key has therefore a number of steps at the end of the bit, exactly adapted t move the tumblers through the required spaces; and as this arrangement admit of almost endless variations, and is extremely simple in itself, very beautif and secure locks have continued to be manufactured on the principle ever sinc it was brought before the public. The facilities of "getting them up" are no so great at Wolverhampton and Birmingham, by the application of machine for fabricating the separate parts of these (as well as other) locks, chiefly b stamping, that the wholesale price of a good Barron's patent cabinet lock do not exceed two shillings; the sale of them is consequently very great.

Although no doubt can be entertained that Barron really invented the lo we have been noticing, it appears from the statements of Mr. Ainger, that th Egyptian locks now in use are constructed upon the same principle as Ba ron's; and as these modern Egyptian locks are the same as those observ upon the great temple at Karnac, the invention which we have been regardi as our countryman's, and of modern date, is upwards of 4000 years old. Th bolt and a fixed part of the Egyptian lock are, as described by Mr. Ainge each pierced with any number of holes, arranged in any chosen form; those i the bolt and in the fixed part coinciding when the bolt is locked. These hol are occupied by pins, which are contained in the fixed part, and descend in the bolt, so as to prevent its motion till they are removed wholly into the fix part. This is effected by a key having the same number and arrangement pins, and of such a length, that they elevate the ends of the pins in the lock the plane of motion between the bolt and the fixed part. This key is intr duced laterally through a long tube, at the end of which it acts vertically up the pins, whose position therefore it is difficult to ascertain. The same pri ciple was afterwards adopted by Mr. Bramah, (who took out a pate for it in 1784,) but without the assistance of wards; his mode of applicati was, however, very different from the Egyptian. In the latter the security ar from a concealment of the number and position of the impediments; in M Bramah's these were discoverable on inspection, and the security depended the various degrees of motion which the several impediments required bef the bolt could be moved. The office which in ordinary locks is performed the extreme point of the key, is, in Bramah's, assigned to a lever, whi cannot approach the bolt till every part of the lock has undergone a change position. The lock may be described as consisting of a common axis, on wh six levers, crossing the face of the lock, are united as in a joint. Each of th rests upon a separate spring, sufficiently strong to bear its weight, or if depres by a superior force, to restore it to its proper position when that force is remov The levers pass through a frame by separate grooves, exactly fitted to th width, but of sufficient depth to allow them a free motion in a perpendicu direction. The joint or carriage of the levers, and the springs on which th rest, are fixed on a circular platform, turning on a centre, and the motion this platform impels the bolt in either direction by means of a lever. inviolable restraint upon this lock, by which means it is subjected only to action of the key, is lodged in a thin plate, bearing at each extremity o block, and having of course a vacant space beneath, equal in height to thickness of the block on which it rests. By this plate the motion of machine is checked or guided in the following manner:—on the edge of the which faces the movement there are six notches, which receive the ends of levers projecting beyond the frame; and while they are confined in this man

of the machine is so totally suspended as to defy every power of art ... To understand in what manner the proper key of this lock over... obstacles, it must be observed that each lever has a notch on its ... and that those notches are disposed as irregularly as possible. To ...chine a capacity of motion, these notches must be brought parallel ..., and, by a distinct but unequal pressure upon the levers, be formed ... in a direct line with the edge of the plate, which the notches are ... to receive. The least motion of the machine whilst the levers are ...on, will introduce the edge of the plate into the groove, which con... power of the springs, will give liberty to the levers to move in a ...rection, as far as the space between the blocks which support the ...mit, and which is sufficient to give the machine the power of acting. The key exhibits six different surfaces, against which the levers ...ively admitted in the operation of opening the lock: the irregu... surfaces shows the unequal and distinct degree of pressure which ...quires to bring them to their proper bearings, in order to put the ...motion. Hence it appears that unless the various heights of the ...ressed on the bit of the key are exactly proportioned to the several ...ecessary to bring the notches into a straight line with each other, ...main immovable. On this principle it would be a matter of great ... any workman, however skilful, to construct a key for the lock ... to his inspection; for the levers, being raised by the subjacent ... equal height in the frame, present a plane surface, and, conse...vey no direction that can be of any use in forming a tally to the ...rface which they present when acting in subjection to the key. ...fore we can contrive a method to bring the notches in the points of ... a direct line with each other, and to retain them in that position ... impression of the irregular surface, which the levers will then ... be taken, the workman will be unable to fit a key to the lock, or ... bolt. If such difficulties occur even when the lock is open to the ... a skilful workman, much more must we suppose it out of the ...e who has not access to the internal parts to make a false key. ...lties render it necessary in making locks of this kind not to fit the ...ck, but to fit the lock to the key. The key must therefore be made ... inequalities upon the surface of the bit worked as chance or fancy ... without any reference to the lock. The key being thus completed ... to the surface of the levers, will, by a gentle pressure, force them ...distances from their common station in the frame, and sink their ...equal depths into the space beneath the plate. While the levers are ...on, the edge of the plate will mark the precise point at which the ...h lever must be expressed. The notches being cut by this direction, ...ity which appears when the levers resume their station in the frame, ...uality of the recesses on the bit of the key, will appear as a seal ...sponding impression. The moving of the bolt, or other parts of ...reby it may be opened, entirely depends on the positive motion of ...c., as any of them would, by being pushed the least degree too ... little, entirely prevent the bolt from being moved or set at liberty: ...hole of the levers are restored to their situation when the bolt is ... the tally, or impression, is totally destroyed, and, consequently, the ... the lock is left wholly dependent on chance *whilst the said key* ... there is no rule whatever to assist in discovering the required posi... or any of the levers, or other movables, whereby the form of the ...y to the opening of the lock might be ascertained. Mr. Bramah ... the number of changes of position that the levers of such a lock are ...before the right one might be discovered, in the following manner:— ...ppose the number of levers, sliders, or other movables, by which the ...shut, to consist of twelve, all of which must receive a different ... change in their position or situation by the application of the key, ... them likewise capable of receiving more or less than its due, either ...ould be sufficient to prevent the intended effect; it remains, therefore,

to estimate the number producible, which may be thus attempted:—Let the denominations of these levers, &c be represented by twelve arithmetical progressionals, we find that the ultimate number of changes that may be made in their place or situation, is 479,001,500; and by adding one more to that number of levers, &c., they would then be capable of receiving a number of changes equal to 6,227,019,500, and so on progressively, by the addition of others in like manner, to infinity. From this it appears that one lock, consisting of thirteen of the above-mentioned levers, sliders, or other movable parts, may (by changing their places only, without any difference in motion or size) be made to require the said immense number of keys, by which the lock could only be opened under all its variations."

Statements like the foregoing, apparently founded upon just reasoning, obtained for Bramah's patent an extraordinary degree of reputation, and, for the patentee, during many years, a very lucrative trade; but this and other improvements induced a corresponding study in the art of picking, which finally obtained a triumph over Bramah's invention; and had it not been for the discovery of new means of baffling the picker's art, by the introduction of *false* notches, the reputation of these admirable locks would have been destroyed; but, from the apparent impossibility of discovering the false from the true notches, or of ascertaining those which assist from those which do not assist in the effect the lock is now deemed inviolable; it is manufactured very extensively, and sold at very moderate prices.

In 1805, Mr. Stansbury, an American, came over to this country with a new lock, which he patented, and was very assiduous in endeavouring to get it introduced; in which attempt, however, he met with so little encouragement, that it might be deemed a failure. Nevertheless, there was sufficient originality in his contrivance to merit a notice in this place: the key was of the ordinary shape of those with a pipe, but longer and narrower in the bit, on the lower side of which were a number of pins projecting from its surface; the key had no wards, and the lock, consequently, none; the bolt was not moved by the key immediately, but through the instrumentality of a revolving circular plate, attached to, and underneath which, was a fixed pin, that took into a notch in the bolt; it was therefore the office of the key to remove the impediments to the motion of the revolving plate, which impediments consisted in a number of pins passing through it and another *fixed* circular plate or bridge underneath, the said pins being pressed through both, and made flush with the surface of the upper by the action of springs rivetted to the bridge. The two plates thus locked together were separated by the projecting pins upon the key, which, entering the holes in the upper plate, pressed the spring pins out of them and turned the plate round. The pin-holes in the circular plates were not opposite to the key-hole, but on one side leading towards the bolt, so that to find them out it was necessary to push the key slightly against the plate whilst turning it round.

Mr. Lawson subsequently took out a patent for a lock, the additional security in which consisted in the employment of a sliding curtain, which is drawn before the key-hole in the act of unlocking, thus rendering it impossible to move the bolt whilst a pick remained in the aperture.

In 1816 a lock was invented by Mr. Kemp, of Cork, the security of which consisted in the adaptation of tumblers or sliders, operated upon by two, three, or more small concentric tubes, of different lengths, placed inside the barrel of the key. These tubes were made of such a length as to push back the pins or sliders that detain the bolt, to the required positions, until each one corresponds with the notch that is cut in it for the projecting part of the bolt. Mr. Kemp calls his invention the *union lock*, from the circumstance that it unites the qualities of Barron's and Bramah's locks; and from the manner in which the combination is effected, it affords, according to the inventor, a greater degree of security than either of the former, or than both of them together, supposing a lock of each kind was placed on the same door; and that a dishonest servant who does not possess any particular ingenuity, may be instructed by a locksmith how to take the requisite impressions of either Barron's or Bramah's

ing, even if he could be intrusted with them only for a few minutes; but this cannot be done with the key of the union lock, as it would require the locksmith to examine it himself, and to make several tools to ascertain its different dimensions, which he could not do without having it in his possession for some considerable time, with leisure to make repeated trials. In this remark of Mr. Kemp's we entirely coincide; and it still applies to all locks hitherto made (1834), that the *keys*, when in the possession of a workman, *may be copied*; and, in many, without possession. Mr. Kemp's invention may supply a partial remedy for this defect; but until a complete one is provided, the art of lock-making is imperfect, and no locks are inviolable.

Viewing the subject in this light, it affords the editor of this work much satisfaction to state, that he has in his possession a lock, the key of which *cannot be copied*; a locksmith possessing no tools by which an exactly similar one can be made; and the machine by which the original one was made, is so arranged as to be deprived of the power of producing another like it. The lock is very simple, very strong, and can be very cheaply made. The cost of a complete machine to make them would be about one hundred pounds; with that they might be manufactured at one-half the expense of any patent lock. The inventor is desirous to have the subject brought before the public under a patent, but want of time to devote himself to such an object at present obliges him to lay it aside.

Locks have been made which required that the key should be a powerful magnet; others, in which an unusual and complicated motion must be given to the key, and others, in which an improper key or instrument would fire a pistol, or ring an alarum, as proposed by the Marquis of Worcester.

Of all the various locks that have of late years been introduced to the notice of the public, Mr. Chubb's has obtained the greatest celebrity. Although it possesses but small claims to novelty, it cannot be denied that it combines, in an eminent degree, the qualities of security, simplicity, strength, and durability; and we think that the persevering and business-like manner in which the ingenious inventor has contrived to fix it before the public eye, has contributed in no small degree to the successful "run" it has had. The chief characteristic of this lock, and that which marks it as Chubb's, is the employment of a lever called a detector, which locks the bolt fast upon any of the tumblers being beyond its assigned range, and shows that some person has been attempting to pick it by a false instrument. In other respects the lock resembles Barron's or Bramah's; and we are disposed to question its boasted superiority over those admirable inventions for a reason which now forces itself upon our attention. In Barron's and Bramah's the picker has no means of knowing whether the tumblers are lifted too high or not; but in Chubb's he has only to put the detector *hors de combat* in the first instance, by a correct thrust from the outside of the door (which might be accurately measured) so as to *fix* it fast in its place, the detector then becomes a stopper to the undue ascent of the tumblers, and the extent of their range is thereby correctly ascertained: thus it appears to us, the *detector* might be converted into a *director* of the means of picking the lock.

In 1829 Mr. Gottlieb took out a patent for improvements in locks, which consisted in the application of a piece of paper over the key-hole, so secured as to prevent its being removed without the introduction of a key passing through it; hence any attempt to break open the lock would be indicated by the rupture of the paper. The paper is introduced and secured by means of a small shield with a hole in it, similar to the key-hole, in a lock plate; this shield is kept down by a spring catch, which cannot be disengaged for the introduction of a fresh piece of paper, except by the proper key, which is furnished with a projecting stud on the side of the key-stem, for the purpose of disengaging the spring catch when turned. As a source of further security, the patentee proposes to employ cheque-paper, with some design engraved upon it; and by having the paper bound in a cheque-book, and a leaf torn off when required, that the paper found in the key-hole at any time being compared with the stump of the leaf in the book, the substitution of another paper would be

discovered. There are few cases in which this plan can be advantageously employed.

Messrs. Carpenter and Young, of Willenhall, in Staffordshire, had a patent in 1830 for improvements in locks. Their object appears, from the specification, to be the production of locks of greater security and stability than the common locks without augmenting the cost; and also to construct a latch-lock, somewhat more convenient in use. The greater degree of security is obtained by having a double set of tumblers, one set attached to, and movable with, the bolt, and the other attached to the plate of the lock in the usual way. Projections from the stationary tumblers fit into slits in the movable ones, when they are simultaneously elevated to a given position; and in addition to this, there are notches cut in the upper and lower sides of the movable tumblers, to fit fixed pins projecting from the plate, just above the notches on the upper side, and just below those of the under side when the door is locked, so that the bolt cannot be withdrawn except by a key, which raises each tumbler to an elevation coinciding precisely with the cuts in the original key, and upon this depends the security. Instead of the usual latch or spring bolt to room-door locks, the patentees cause this part to drop into a notch in the striking plate after it has been elevated by passing over an inclined plane upon it. In connexion with this latch is a tumbler, by which it is elevated through the instrumentality of a key, by a handle on one side of the door and a key on the other, or by the key, without using the handle. These contrivances have manifest advantages, and are easily executed by any locksmith.

The application of an inviolable lock to boxes sent by mails or other conveyance, containing money or other valuable property, that can be opened only at stated times, is, of course, an object of desirable attainment in a commercial country like this. For effecting this object a patent was taken out in November, 1831, by William Rutherford, jun. of Jedburgh, in Scotland. This gentleman being a bank agent, had no doubt sensibly felt the importance of having the means of transmitting, from one town to another, bankers' parcels with perfect safety. With this view he introduces against the end of the bolt a circular stop-plate, to prevent the withdrawal of the bolt till the circular plate, which is put in rotation by clock-work, shall have revolved so as to bring a notch opposite the end of the bolt. Now as this notch can be set at pleasure to any required distance from the end of the bolt, the lock may be secured against being opened by its own or any other key, till any assigned number of hours after it has been locked; and as the rate of travelling is known, the box can be secured from robbery till it shall have reached its destination. When this fastening is used for portable boxes or packages, it must be put in motion, and its motion regulated by springs; but when it is to be applied to closets or safes, the most simple mode of giving motion will be by a descending weight, and of regulation by a pendulum; the actuating weight may then be made to rest upon, and disengage a locking bar in connexion with the bolt of the lock, at any assigned number of hours after the fastening has been effected. In this case all that is necessary is to cause the weight to descend down a vertical scale, divided into hours, and to raise it to any assigned number when the door is locked. A still farther security is obtained by the locking-bar itself being prevented from being disengaged by any pressure, except by the descent of the weight, which is made to come, in its descent, into contact with an inclined projection from the lower end of the hour-scale, sending it back and disengaging the locking-bar from a notch therein.

We might extend our descriptive account of locks to numerous others, containing arrangements of parts differing from the foregoing, and each possessing a certain degree of merit, as respects one or more of the necessary qualifications of a lock; but the detail would be uninteresting and profitless; we shall, therefore here close our account of locks extraordinary, by giving the reader a summary of those in general use, of which there are full a hundred times as many as of the former. Indeed, by far the greater number of locks in use are not required as a security against the dexterous thief, but principally as a check upon the intrusive curiosity and meddling of children and servants; and of the

numerous tribe of petty pilferers, there are few who have sufficient knowledge of the nature of common locks to succeed in, or who are daring enough to attempt the picking of them. We have already noticed, at page 104, that a vast quantity of locks are made without any wards or other securities whatever, but the bolt; and these having been *stamped* with the public *approbation*, (to our own knowledge for nearly half a century,) what need is there to give two guineas, or two shillings for a lock, when a satisfactory one can be obtained for *two-pence? Useful* trunk locks are indeed manufactured by thousands of grosses, at a wholesale price not exceeding *one penny each!* They are chiefly the product of the stamping press; but the malleable-cast-iron-founder is not behind-hand in demonstrating the power of his art in this manufacture. The technical term for wards, in the lock-trade, is *wheels;* thus, they are successively demonstrated according to this point of their quality, 1 *wheel*, 2 *wheels*, 3 *wheels*, 4 *wheels;* and to these terms there is a prefixture called *plain*, which means, no wards at all. The wards are simply short pieces of thin plate iron, rivetted on the upper or lower plate, or on both plates, opposite or near to the key hole. If the wards are of a better quality, they are dignified by a higher title, as *one ward round, two wards round*, &c.; which is when the wards make an entire circle, or nearly so, of the lock. They are called L *ward*, or T *ward*, or Z *ward*, when the sectional form of the wards represents the figure of those letters. *Copper wards*, signify the employment of that metal, instead of iron, to adapt them for use in cellars, and other damp places. *Solid wards* are much used, as they are substantial and not dear, being readily made by casting in brass, and turning in the lathe; and they largely assist in making *fancy locks*. The term *fine*, in the lock trade, has about the same meaning as the ordinary application of that adjective to smart persons; they are a little glazed on the surface, to dazzle the eye, but are coarse enough underneath; and they have two bright-headed screws, one or both of which are usually loose. The quality of the plates, bridges, staples, springs, bolts, and other parts of the interior of a lock, is made to assimilate with the quality of the wards, unless ordered to the contrary.

Locks, according to their uses, may be divided into two classes, namely, in-door locks and out-door locks; and of each class there are numerous kinds, sizes, and qualities. We will name the principal, that persons who want them may understand the distinctive names by which they are known in the trade. Commencing with the in-door class, the first kind that occupies our attention are those upon the front doors of houses, called *draw-back* locks, as the bolt, when not locked, is made to spring to, and has a knob for the purpose of drawing it back, they are generally made of iron, and they are, therefore, further designated by the term *iron-rim*, to distinguish from those having wooden stocks, called *spring-stock-locks*, which are of a cheaper and less elegant kind, and are therefore more frequently put to back doors. For the doors of rooms, there are three principal kinds, distinguished by the names of *mortise*, *brass-case*, and *iron-rim* locks. Formerly the latter kind were put on the doors of parlours, and even drawing rooms; but their unsightly appearance soon caused the substitution of the brass-cased locks. The bright yellow metal was long a favourite, but ingenuity, seconded by good taste, introduced the mortise-lock, which is now rendered so cheap, that scarcely any new houses, excepting those for the very poor, are built without them. By the aid of machinery, and a minute division of labour, mortise-locks are made at an astonishingly low price at Wolverhampton; and the workmanship of even the commonest kind is substantial and durable. As room-door locks are before every body's eyes, it will only be necessary to observe, that all such are specified in the following manner. If there be only one bolt to it which the key shoots, it is called a *dead-lock*, or *one-bolt lock;* if there be in addition a spring bolt, with a handle to open it, it is called a *two-bolt lock;* and if there be a private bolt besides, it is called a *three-bolt lock.* It is also necessary to specify the kind of handles required, (*knobs or rings, &c.*); the hand (*right* or *left*); the thickness of the doors; and if plain wards, round wards, tumblers, patent, &c.

Under the general term of cabinet locks, are comprehended a great variety of kinds, such as *cupboard*, *book-case*, *desk*, *portable desk*, *table*, *drawer*, or *till*, *box*,

chest, caddy, &c. These also partake of three forms, as respects the manner of fixing them. They are called *straight*, when the plate of the lock is to be screwed with its flat side against the wood-work; *cut*, when the wood is to be cut away to let in the lock flush with the surface; and *mortise*, when a mortise cavity is to be made edgeways in the wood for its reception. The sizes of these locks vary from 1 to 5 inches; they are made in both iron and brass, and the qualities are distinguished by the terms already mentioned.

Of the out-door locks, those used for gates, stables, sheds, &c. are for the most part wooden *stock-locks*; of these there are many qualities; the common or *Banbury*, the *bastard*, the *fine*, and many qualities above the latter, which would require too lengthened an explanation; the internal parts being made of copper, iron, and brass. There are also the D and the P gate locks, and the very numerous family of padlocks; for information upon which we must refer the reader to his locksmith, as a volume might be filled with those and others which we have necessarily omitted.

LOG. A machine or apparatus used to measure the rate of a ship's velocity through the water. For this purpose there are various inventions; but the one mostly used is the following, and called the common log. It is a piece of thin board, forming the quadrant of a circle of about six inches radius, and balanced by a small plate of lead nailed on the circular part, so as to swim perpendicularly in the water, with the greater part immersed. The log line is fastened to the log by means of two legs, one of which is knotted through a hole at one corner, while the other is attached to a pin fixed in a hole at the other corner, so as to draw out occasionally. The log line, being divided into certain spaces, which are in proportion to an equal number of geographical miles, as a half or a quarter minute is to an hour of time, is wound upon the reel. The whole is employed to measure the ship's head-way in the following manner: the reel being held by one man, and the half minute glass by another, the mate of the watch fixes the pin, and throws the log over the stern, which swimming perpendicularly, feels an immediate resistance, and is considered as fixed; the line being slackened over the stern to prevent the pin coming out. The knots are measured from a mark on the line, at the distance of 12 or 15 fathoms from the log; the glass is therefore turned at the instant that the mark passes over the stern; and as soon as the sand in the glass has run out, the line is stopped; the water being then on the log, dislodges the pin, so that the board now only presenting its edge to the water, is easily drawn aboard. The number of knots and fathoms which had run off at the expiration of the glass, determines the ship's velocity. The half-minute glass and divisions on the line should be frequently measured, to determine any variation in either of them, and make an allowance accordingly. If the glass runs 30 seconds, the distance between the knots should be 50 feet. When it runs more or less, it should, therefore, be corrected by the following analogy:—as 30 is to 50 so is the number of seconds of the glass to the distance between the knots upon the line. The heat or moisture of the weather having often a considerable effect upon the glass, so as to make the sand run faster or slower, it should be frequently tried by the vibration of a pendulum. The inventor of this simple and admirable contrivance is unknown; and no mention of it occurs till the year 1607, in an account of an East India voyage, published by Samuel Purchas. Since that period, the log has been in general use, and many improvements have been made upon it. One of the most conspicuous of these improvements, is that invented by Mr. James Hookey, a midshipman in the navy, who received a honorary medal from the Society of Arts for the same.

The advantages gained by Mr. Hookey's invention are, that it gives the distance the ship runs more correctly, as it remains more stationary in the water than the one generally in use; and when required to be hauled into the ship, by giving it a sudden jerk, the toggle swivels round, and disengages the line from the spring, in consequence of which, the log ship reverses its position, and may then be pulled into the ship with the greatest ease. With respect to the lines, Mr. Hookey recommends, that they be saturated in a composition of oil, which makes them more buoyant and pliant, and prevents kinking; it likewise prevents

contracting, which in a new line is about 20 feet in 50 fathoms. As many accidents are likely to occur by getting a false depth of water, in conse- of the contraction of the line attached to the lead, it becomes an object of attention to prevent the possibility of such accidents taking place. is formed like a fish. *Fig.* 1 represents one running out, and *Fig.* 2 ne, in the act of being pulled in; *r* the toggle, *s* the spring; the eye of is put on the toggle, which is then pushed under the spring; the flap falls down, and the fish runs out. When the line is taught, a sudden make the toggle pass the spring and let go the line; the fish then round, the flap board *t* closes, and it is easily pulled in. *Fig.* 3 shows side; the flap-board *t* is jointed to the fish by the strap of the copper passes round a pin *llll*, and this pin is held by the copper strap *w*; is attached to the log by a loop which goes in at the mouth, and is held which forms the eye; the flap-board *t*, if made of copper, has a piece rivetted to it in the middle to stiffen it; if made of wood, a slip of lead is rivetted on, to make it heavy enough to drop down readily when into the water. *Fig.* 4 is a top view of one made thin and wide, like a , the spring *s*, which holds the toggle is underneath, beneath the fish

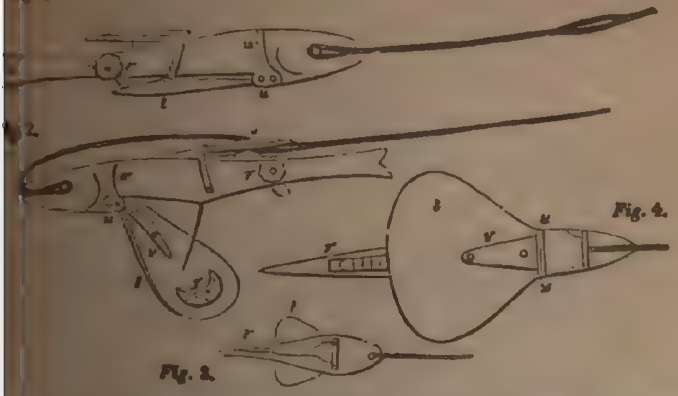


Fig. 1. Fig. 2. Fig. 3. Fig. 4.

flap board *t*; the spring may be above or below in either case. The are the instructions given for using the log-ship. The eye in the be put over the toggle, on the tail of the fish, and when the line is all from the reel, and it becomes taught, by giving it a sudden jerk, the will swivel out, the fish will then reverse its position, float on the sur- the water, and may be hauled into the ship with the greatest ease. it is necessary to shift the line at the head of the fish, knock out the peg the eye, and the line will then disengage itself; and in attaching line, make an eye in it, and pass it into the mouth of the fish perpen- ly, through which put the peg that forms the eye, and it will be quite The inventor strongly recommends that all log lines, and lines to the should be saturated for one hour in linseed and lamp oil, three-fourths of and one-fourth of the latter well mixed together, after which, hang to dry; contraction will thus be prevented, and they will be pliable

GARITHMS are series of artificial numbers, so arranged with reference of natural numbers that the addition of the logarithms shall correspond multiplication of the natural numbers belonging to them; and sub- of logarithms answers for division; while involution, or the raising of is performed by the multiplication of logarithms; and evolution, or the of roots, by the division of logarithms.

To illustrate this, let us take—

For Natural Numbers the Geometrical Series . .	1	10	100	1000	10000	100000	1000000
And for their Logarithms the Arithmetical Series	0	1	2	3	4	5	6

From this it appears that the log. of 1 is 0, that of 10 is 1, of 100 is 2, &c.; that the log. of any number below 10 is a fraction, above 10 and under 100 is 1; with a fraction, and between 1000 and 100, is 2 with a fraction, and so on. Hence it is evident that the portion of a log. which constitutes the whole number, and is denominated the Index, is always one less than the numbers of figures for which it is the log. This general rule is so easy of application, that the Indexes of Logarithms are never printed in the tables, but left to be supplied by the operator.

The rule for determining the Index descends as well as ascends, and applies with equal facility to numbers below and above unity; but when applied to numbers below unity, it must be distinguished by a negative sign thus—

NATURAL NUMBER.		LOGARITHM.
·000001	. . . .	$\bar{6}$·0000000
·00001	. . . .	$\bar{5}$·0000000
·0001	. . . .	$\bar{4}$·0000000
·001	. . . .	$\bar{3}$·0000000
·01	. . . .	$\bar{2}$·0000000
·1	. . . .	$\bar{1}$·0000000
1·	. . . .	0·0000000
10·	. . . .	1·0000000
100	. . . .	2·0000000
1000	. . . .	3·0000000
&c.		&c.

To furnish the means of illustrating this important subject by a few examples, and to give the reader an opportunity of working cases by logarithms when the numbers to be operated upon are not very large, we subjoin

A TABLE OF LOGARITHMS OF NUMBERS,

From 1 to 1000.

Number 1 to 100, and their Logarithms.

1	·0000000	21	·3222193	41	·6127839	61	·7853298	81	·9084850
2	·3010300	22	·3424227	42	·6232493	62	·7923917	82	·9138139
3	·4771213	23	·3617278	43	·6334685	63	·7993405	83	·9190781
4	·6020600	24	·3802112	44	·6434527	64	·8061800	84	·9242793
5	·6989700	25	·3979400	45	·6532125	65	·8129134	85	·9294189
6	·7781513	26	·4149733	46	·6627578	66	·8195439	86	·9344985
7	·8450980	27	·4313638	47	·6720979	67	·8260748	87	·9395193
8	·9030900	28	·4471580	48	·6812412	68	·8325089	88	·9444827
9	·9542425	29	·4623980	49	·6901961	69	·8388491	89	·9493900
10	·0000000	30	·4771213	50	·6989700	70	·8450980	90	·9542425
11	·0413927	31	·4913617	51	·7075702	71	·8512583	91	·9590414
12	·0791812	32	·5051500	52	·7160033	72	·8573325	92	·9637878
13	·1139434	33	·5185139	53	·7242759	73	·8633229	93	·9684829
14	·1461280	34	·5314789	54	·7323938	74	·8692317	94	·9731279
15	·1760913	35	·5440680	55	·7403627	75	·8750613	95	·9777236
16	·2041200	36	·5563025	56	·7481880	76	·8808136	96	·9822712
17	·2304489	37	·5682017	57	·7558749	77	·8864907	97	·9867717
18	·2552725	38	·5797836	58	·7634280	78	·8920946	98	·9912261
19	·2787536	39	·5910646	59	·7708520	79	·8976271	99	·9956352
20	·3010300	40	·6020600	60	·7781513	80	·9030900	100	·0000000

NUM.	LOG.	NUM.	LOG.	NUM.	LOG.	NUM.	LOG.	NUM.	LOG.
100	0000000	150	1760913	200	3010300	250	3979400	300	4771213
101	0043214	151	1789769	201	3031961	251	3996737	301	4785665
102	0086002	152	1818436	202	3053514	252	4014005	302	4800069
103	0128372	153	1846914	203	3074960	253	4031205	303	4814426
104	0170333	154	1875207	204	3096302	254	4048337	304	4828736
105	0211893	155	1903317	205	3117539	255	4065402	305	4842998
106	0253059	156	1931246	206	3138672	256	4082400	306	4857214
107	0293838	157	1958997	207	3159703	257	4099331	307	4871384
108	0334238	158	1986571	208	3180633	258	4116197	308	4885507
109	0374265	159	2013971	209	3201463	259	4132998	309	4899585
110	0413927	160	2041200	210	3222193	260	4149733	310	4913617
111	0453230	161	2068259	211	3242825	261	4166405	311	4927604
112	0492180	162	2095150	212	3263359	262	4183013	312	4941546
113	0530784	163	2121876	213	3283796	263	4199557	313	4955443
114	0569049	164	2148438	214	3304138	264	4216039	314	4969296
115	0606978	165	2174839	215	3324385	265	4232459	315	4983106
116	0644580	166	2201081	216	3344538	266	4248816	316	4996871
117	0681859	167	2227165	217	3364597	267	4265113	317	5010593
118	0718820	168	2253093	218	3384565	268	4281348	318	5024271
119	0755470	169	2278867	219	3404441	269	4297523	319	5037907
120	0791812	170	2304489	220	3424227	270	4313638	320	5051500
121	0827854	171	2329961	221	3443923	271	4329693	321	5065050
122	0863598	172	2355284	222	3463530	272	4345689	322	5078559
123	0899051	173	2380461	223	3483049	273	4361626	323	5092025
124	0934217	174	2405492	224	3502480	274	4377506	324	5105450
125	0969100	175	2430380	225	3521825	275	4393327	325	5118834
126	1003705	176	2455127	226	3541084	276	4409091	326	5132176
127	1038037	177	2479733	227	3560259	277	4424798	327	5145478
128	1072100	178	2504200	228	3579348	278	4440448	328	5158738
129	1105897	179	2528530	229	3598355	279	4456042	329	5171959
130	1139434	180	2552725	230	3617278	280	4471580	330	5185139
131	1172713	181	2576786	231	3636120	281	4487063	331	5198280
132	1205739	182	2600714	232	3654880	282	4502491	332	5211381
133	1238516	183	2624511	233	3673559	283	4517864	333	5224442
134	1271048	184	2648178	234	3692159	284	4533183	334	5237465
135	1303338	185	2671717	235	3710679	285	4548449	335	5250448
136	1335389	186	2695129	236	3729120	286	4563660	336	5263393
137	1367206	187	2718416	237	3747483	287	4578819	337	5276299
138	1398791	188	2741578	238	3765770	288	4593925	338	5289167
139	1430148	189	2764618	239	3783979	289	4608978	339	5301997
140	1461280	190	2787536	240	3802112	290	4623980	340	5314789
141	1492191	191	2810334	241	3820170	291	4638930	341	5327544
142	1522883	192	2833012	242	3838154	292	4653829	342	5340261
143	1553360	193	2855573	243	3856063	293	4668676	343	5352941
144	1583625	194	2878017	244	3873898	294	4683473	344	5365584
145	1613680	195	2900346	245	3891661	295	4698220	345	5378191
146	1643529	196	2922561	246	3909351	296	4712917	346	5390761
147	1673173	197	2944662	247	3926970	297	4727564	347	5403295
148	1702617	198	2966652	248	3944517	298	4742163	348	5415792
149	1731863	199	2988531	249	3961993	299	4756712	349	5428254

NUM.	LOG.	NUM.	LOG.	NUM.	LOG.	NUM.	LOG.	NUM.	LOG.
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	6989700	550	7403627
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	6998377	551	7411516
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	7007037	552	7419391
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	7015680	553	7427251
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	7024305	554	7435098
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	7032914	555	7442930
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	7041505	556	7450748
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	7050080	557	7458552
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	558	7466342
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	559	7474118
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	560	7481880
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	561	7489629
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	562	7497363
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	563	7505084
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	564	7512791
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	565	7520484
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	566	7528164
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	567	7535831
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	568	7543483
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	569	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	570	7558749
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	571	7566361
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	572	7573960
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	573	7581546
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	574	7589119
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	575	7596678
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	576	7604225
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	577	7611758
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	578	7619278
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	579	7626786
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	580	7634280
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	581	7641761
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	582	7649230
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	583	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	584	7664128
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	585	7671559
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	586	7678976
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	587	7686381
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	588	7693773
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	589	7701153
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	590	7708520
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	591	7715875
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	592	7723217
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	593	7730547
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	594	7737864
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	595	7745170
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	596	7752463
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	597	7759743
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	598	7767012
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	599	7774268

NUM	LOG.	NUM.	LOG.	NUM.	LOG.	NUM.	LOG.	NUM.	.
850	9294189	880	9444827	910	9590414	940	9731279	970	98
851	9299296	881	9449759	911	9595184	941	9735896	971	98
852	9304396	882	9454686	912	9599948	942	9740509	972	98
853	9309490	883	9459607	913	9604708	943	9745117	973	98
854	9314579	884	9464523	914	9609462	944	9749720	974	98
855	9319661	885	9469433	915	9614211	945	9754318	975	98
856	9324738	886	9474337	916	9618955	946	9758911	976	98
857	9329808	887	9479236	917	9623693	947	9763500	977	98
858	9334873	888	9484130	918	9628427	948	9768083	978	99
859	9339932	889	9489018	919	9633155	949	9772662	979	99
860	9344985	890	9493900	920	9637878	950	9777236	980	991
861	9350032	891	9498777	[illegible]	9642596	[illegible]	9781805	981	991
862	9355073	892	9503649	922	9647309	952	9786369	982	99
863	9360108	893	9508515	923	9652017	953	9790929	983	99
864	9365137	894	9513375	924	9656720	954	9795484	984	99
865	9370161	895	9518230	925	9661417	955	9800034	985	993
866	9375179	896	9523080	926	9666110	956	9804579	986	993
867	9380191	897	9527924	927	9670797	957	9809119	987	994
868	9385197	898	9532763	928	9675480	958	9813655	988	994
869	9390198	899	9537597	929	9680157	959	9818186	989	995
870	9395193	900	9542425	930	9684829	960	9822712	990	995
871	9400182	901	9547248	931	9689497	961	9827234	991	996
872	9405165	902	9552065	932	9694159	962	9831751	992	996
873	9410142	903	9556878	933	9698816	963	9836263	993	996
874	9415114	904	9561684	934	9703469	964	9840770	994	997
875	9420081	905	9566486	935	9708116	965	9845273	995	997
876	9425041	906	9571282	936	9712758	966	9849771	996	998
877	9429996	907	9576073	937	9717396	967	9854265	997	998
878	9434945	908	9580858	938	9722028	968	9858754	998	999
879	9439889	909	9585639	939	9726656	969	9863238	999	999

It is not our province, in this brief article, to explain the use of the Logarithmic Tables, as whoever possess such have of course their author' explanations, and therefore the following illustrative examples are selec suit the table here given.

Multiplication, as already stated, is performed by the *addition* of rithms, thus:—

To multiply 368 by 22·5, we place opposite to each other the

Numbers	and their	Logarithms.	
368	....	2·5658478	Add.
22·5	....	1·3521825	
Product of Numbers 8280·	....	3·9180303	Sum of L

Here the first factor, 368, being a whole number consisting of *three* : has for its index 2; and the second, 22·5, having but *two* figures, with decimal part, has for its index 1. To these are subjoined the decimal p of the logarithms taken from the Table, and the sum of the two being f the Table opposite to 828, which would be the answer were the index 2; bu index is 3, the answer must be made to consist of *four* figures, which is d supplying to the right of the figures a cipher, making the answer, as 8280.

Required the capacity of an excavation, whose length is 295, breadth 128, and depth 25 feet.

	NUMBERS.		LOGARITHMS.	
	295	....	2·4698220	
	128	....	2·1072100	
	25	....	1·3979400	
Product .	944000	....	5·9749720	Sum.

Again, let the numbers 3·2, 25, 1·12, ·125, ·015, and ·004 be continually multiplied together.

	NUMBERS.		LOGARITHMS.
	3·2	....	0. 5051500
	25·	....	1· 3979400
	1·12	....	0· 0492180
	·125	....	$\bar{1}$· 0969100
	·015	....	$\bar{2}$· 1760913
	·004	....	$\bar{3}$· 6020600
Product	·000672	....	$\bar{4}$· 8273693

The number in the table corresponding with the decimal part of the sum of these logarithms is 672, but as the index is $\bar{4}$ there must be three cyphers prefixed to this number to constitute the product or answer which is therefore ·000672.

Division, being the reverse of Multiplication, and performed by subtraction of logarithms, requires but little explanation.

For illustration, let 944000 be divided by 3200, thus:—

	NUMBERS.		LOGARITHMS.	
Dividend	944000	....	5·9749720	From
Divisor. .	3200	....	3·5051500	Substract.
Quotient .	295	....	2·4698220	Difference.

Again, let ·00815 be divided by ·0025.

	NUMBERS.		LOGARITHMS.
	.00815	. .....	3·9111576
	.0025	....	2·3979400
Quotient. .	326	....	1·5132176

Let 493 be divided by 937.

	NUMBERS.		LOGARITHMS.
Dividend. .	493	....	2·6928469
Divisor. . .	937	....	2·9717396
Quotient .	·526		$\bar{1}$·7211073

Here the logarithm to be subtracted being the greater of the two, the index of the difference is $\bar{1}$, which renders the quotient a decimal.

Involution, or the raising of powers, is performed by multiplying the logarithm of the given number by the index of the power to which it is required to be raised, thus:—

Let 26 be squared, or raised to the second power.

NUMBERS.		LOGARITHMS.	
26	....	1·4149733	
		·2	
Power 676	....	2·8299466	Product.

Required the cube root, or third power of 9.

NUMBERS.		LOGARITHMS.
9	....	0·9542425
		3
Power ... 729	....	2·8627275

Required the 9th power of 1.05, which will be the amount of 1*l.* in years, at 5 per cent. compound interest.

NUMBERS.		LOGARITHMS.
1·05	....	0·0211893
		9
Amount.. 1·55 or 1*l.* 11*s.*	....	0·1907037

From this example it is manifest that the amount of money laid out at pound interest for 50, 100, or any other number of years, can be found by rithms with the greatest facility, though the operation by common arith is very tedious, requiring a distinct multiplication for each year.

Evolution, or the extraction of roots, is performed by dividing the loga of the given number by the index of the root required. Let this be illust by finding the square root of 324.

NUMBERS.		LOGARITHMS.
324	....	2)2·5105450
Root ... 18	....	1·2552725

Required the ninth root of 1·55

NUMBERS.		LOGARITHMS.
1·55	....	9)0·1903317
Root ... 1·05	....	0·0211479

As it may occasionally be desirable to apply the foregoing table to num beyond its limits, the manner of doing so is subjoined.

To find the logarithm of a number exceeding three figures, it is evident the logarithm of the first three must be augmented by such a proportion c difference between it and the next greater logarithm, as the remaining fi of the given number bears to unity with as many cyphers as may be requ thus—to find the logarithm of 47583, the logarithm of the first three fi 475 is 6766936, and the next greater is—

6776070

9134 their difference.

Now take the proportion as 1 : ·9134 : : 83 : 75

83

27302

73072

1,0000)75·8022, or 7496 nearly · which being a

to the first logarithm, gives 4·6774516 for the logarithm of 47583. On the contrary, if the number be required for a logarithm not to be found in the table, to the first three figures corresponding with the next less logarithm, are to be subjoined the result of the following proportion; viz.—As the difference between the next greater and next less logarithm is to unity, with as many cyphers as may be required, so is the difference between the given logarithm and the next less to the figures to be subjoined to those found in the table. Thus—Suppose it were required to find the natural number corresponding with 4·6968455

The next less logarithm in the table is	6963564
The next greater	6972293
Difference . .	872·9
The given logarithm	6968455
Next less	6963564
Difference . . .	4891

Now—As 8729 : 100 : : 4891 : 56

```
                    100
            8729)489100(56
                 43645
                 -----
                  52650
                  52374
```

Which being subjoined to 497, the three figures found in the table opposite to the next less logarithm, give 49756 for the number of the given logarithm.

LOGWOOD. A hard compact wood, so heavy as to sink in water; of a fine grain, capable of being polished, and so durable, as to be scarcely susceptible of decay. Its predominant colour is red, tinged with orange, yellow, and black. It yields its colour both to spirituous and watery menstrua. Alcohol extracts it more readily and copiously than water. The colour of its dye is a fine red, inclined a little to violet or purple, which left to itself, becomes yellowish, purple, and at length black. Acids turn it yellow, alkalies deepen the colour, and give it a purple or violet hue. A blue colour is obtained from logwood, by mixing verdigris with it in the dye bath. The great consumption of logwood is for blacks, to which it gives a lustre and velvety cast; it is also extensively used as a red, purple, or black dye to beech, and various white woods.

LONGIMETRY. The measuring of lengths and distances, both accessible and inaccessible. Accessible distances are measured by the application of some lineal measure, as a foot, a chain, &c. Inaccessible distances are measured by taking angles, &c. by means of proper instruments; such as the circumferentor, quadrant, and theodolite.

LOOM. A machine for weaving cloth, of which there are various kinds. See Weaving.

LOZENGES, or Troches, are small articles of confectionery, sometimes medicated, and usually made up of the form of thick wafers. The basis of their composition is refined sugar, which is finely pulverised and sifted, then mixed up in a mortar, with just a sufficient quantity of thick mucilage, to make a very firm paste; to which is added the essential oil or other flavouring ingredient or medicament. When the paste, so made, is of the right consistence to be rolled out into a solid and smooth sheet, that operation should be quickly performed by a cylindrical roller, the ends of which should run upon slips or projections above the board, of the thickness of the intended lozenge. Thus rolled out, the lozenges should be quickly cut out with the punch or cutter; which is usually the hollow frustrum of a cone, with sharp edges at the narrow end, and

is made either of tinned plate, iron, or steel. As soon as these are c[illegible] remaining pieces which formed the interstices between the lozenges, [illegible] rolled up, or beaten together in a mortar, then rolled and cut out agai[illegible] operation continued, until the whole material is used up. But if furthe[illegible] are required of the article under operation, then the remnants of one c[illegible] be added to the succeeding batch. In the pharmacopeias, gum tra[illegible] recommended as the mucilage to be used in making medicinal lozenges[illegible] makers, however, rarely use this gum, as besides being much dearer, [illegible] venient in use, and does not make so elegant a lozenge as gum Arabic [illegible] The latter when in proper quantity, (which is about one ounce of very [illegible] lage to a pound of finely powdered sugar,) gives to the lozenges made [illegible] a semi-transparency and hardness, which is regarded in the trade a[illegible] a well-manufactured article. When essential oils, (such as pepperm[illegible] cinnamon, &c.) are used as the flavouring ingredients, they should no[illegible] until the paste is otherwise nearly completed, as their great volatilit[illegible] waste of their essential properties when long under the hands of th[illegible] In making lozenges containing balsams, such as the *tolu*, the balsa[illegible] advantageously mixed with the mucilage; and those in which pow[illegible] as ginger are to be mixed, the manner of performing it is a matte[illegible] ference.

LUTE, or LUTING. A mixed, tenacious, ductile substance, wh[illegible] applied between the junctures of distillatory and other vessels, grows [illegible] drying, and effectually stops up the crevices. Lutes are of differ[illegible] according to the nature of the operations to be made. When vapours [illegible] liquors, and such as are not corrosive, are to be contained, it is suf[illegible] surround the joiner of the receiver to the nose of the alembic, or of [illegible] with slips of paper or of linen, covered with flour paste. In such [illegible] slips of wet bladder are very conveniently used. When more penetr[illegible] dissolving vapours are to be contained, a lute is to be employed of [illegible] slacked in the air and beaten into a liquid paste with the whites of eg[illegible] paste is to be spread upon linen slips, which are to be applied exa[illegible] joinings of the vessels. This lute is very convenient, easily dries, [illegible] solid, and sufficiently firm. Of this lute, vessels may be formed har[illegible] to bear polishing on the wheel. When acid or corrosive liquors, are [illegible] tained, recourse is had to *fat lute;* which is made of finely powd[illegible] sifted through a fine sieve, and moistened with water; this paste is [illegible] beaten in a mortar with boiled linseed oil, rendered drying by litharge. [illegible] easily takes and retains the forms given to it. It is generally rolled i[illegible] drical sticks of a convenient size for use. They are applied by flatte[illegible] to the joinings of the vessels, which ought to be perfectly dry, becaus[illegible] moisture would prevent the lute from adhering. When the joining[illegible] closed with this fat lute, the whole is to be covered with slips of lin[illegible] with lute of lime, and whites of eggs. These slips are to be fas[illegible] packthread. The second lute is necessary to keep on the fat lute, be[illegible] latter remains soft, and does not become solid enough to stick on al[illegible] porcelain clay, mixed with a solution of borax, is well adapted to ir[illegible] the part received into an aperture being smeared with it.

M.

MACHINE signifies anything used to augment or regulate force [illegible] The simplest machines, namely, the lever, the wheel and axle, the [illegible] inclined plane, the wedge and the screw, are usually denominated t[illegible] nical powers, since all machinery is necessarily compounded of som[illegible] hence a machine is a combination, or a peculiar modification of s[illegible] mechanical powers.

MADDER. A substance very extensively employed in dyeing, [illegible] root of a trailing plant that grows very abundantly in the south of E[illegible] is cultivated in England and Holland also; but the best is said t[illegible]

brought from Smyrna and Cyprus. The roots of the plant are carefully peeled, dried in the air, and afterwards in a kiln, in the same way as hops are dried in Kent. They are then chipped and pulverized. The best roots are about the thickness of a goose-quill; semi-transparent, of a reddish colour and strong smell. The red colouring matter of madder is soluble in alcohol, which, on evaporation, leaves a residuum of a deep red. Fixed alkali forms in this solution a violet, the sulphuric acid a fawn coloured, and the sulphate of potash a fine red precipitate. A variety of shades are obtained by the addition of alum, chalk, nitre, sugar of lead, and the muriate of tin.

MAGIC. The imposture by which a few individuals who had become acquainted with some of the more remarkable phenomena of nature, and the operations of chemistry, managed to enslave the minds and bodies of their ignorant fellow-creatures. An acquaintance with the motions of the heavenly bodies, and the variations in the state of the atmosphere, enabled its possessor to predict astronomical and meteorological phenomena, with a frequency and accuracy which could not fail to invest him with a divine character. The power of bringing down fire from heaven, even at times when the electric influence was itself in a state of repose, could be regarded only as a gift from heaven. The power of rendering the human body insensible to fire, was an irresistible instrument of imposture; and in the combinations of chemistry, and the influence of drugs and soporific embrocations on the human frame, the ancient magicians found their most available resources. The secret use which was thus made of scientific discoveries, and of remarkable inventions, has no doubt prevented many of them from reaching the present times; but though we are very ill informed respecting the progress of the ancients in various departments of the physical sciences, yet we have sufficient evidence that almost every branch of knowledge had communicated its wonders to the magician's budget; and we may even obtain some insight into the scientific acquirements of former ages, by diligent study of their fables and their miracles.

The science of *acoustics* furnished the ancient sorcerers with some of their best deceptions. The imitation of thunder in their subterranean temples, could not fail to indicate the presence of a supernatural agent. The golden virgins, whose ravishing voices resounded through the temple of Delphos; the stone from the river Pactolus, whose trumpet notes scared the robber from the treasure which it guarded; the speaking head, which uttered its oracular responses at Lesbos; and the vocal statue of Memnon, which began at break of day to accost the rising sun,—were all deceptions derived from science, and from a diligent observation of the phenomena of nature.

The principles of *hydrostatics* were equally available in the work of deception. The marvellous fountain which Pliny describes in the island of Andros as discharging wine for seven days, and water for the rest of the year; the spring of oil which broke out in Rome to welcome the return of Augustus from the Sicilian war; the three empty urns which filled themselves with wine at the annual feast of Bacchus in the city of Elis; the glass tomb of Belus, which was full of oil, and which, when once emptied by Xerxes, could not again be filled, the weeping statues, and the perpetual lamps of the ancients;—were all the obvious effects of the equilibrium and pressure of fluids.

Although we have no direct evidence that the philosophers of antiquity were skilled in *mechanics*, yet there are indications of their knowledge, by no means equivocal, in the erection of the Egyptian obelisks, and in the transportation of huge masses of stone, and their subsequent elevation to great heights in their temples. The powers which they employed, and the mechanism by which they operated, have been studiously concealed; but their existence may be inferred from the results otherwise inexplicable, and the inference derives additional confirmation from the mechanical arrangements which seem to have formed a part of their religious impostures. When in some of the infamous mysteries of ancient Rome, the unfortunate victims were carried off by the gods, there is reason to believe that they were hurried away by the power of machinery; and when Apollonius, conducted by the Indian sages to the temple of their gods, felt the earth rising and falling beneath his feet like the agitated sea, he was no

scene placed upon a moving floor, capable of imitating the heavings of the waves. The rapid descent of those who consulted the oracle in the cave of Trophonius—the moving tripods which Apollonius saw in the Indian temples of the walking statues of Antium, and in the temple of Hierapolis—and the wooden pigeon of Archytas, are specimens of the mechanical resources of ancient magic.

But of all the sciences, *optics* is the most fertile in marvellous expedients. The power of bringing the remotest objects within the very grasp of the observer, and of swelling into gigantic magnitude the almost invisible bodies of the material world, never fails to inspire with astonishment even those who understand the means by which these prodigies are accomplished. The ancients, indeed, were not acquainted with those combinations of lenses and mirrors which constitute the telescope and the microscope; but they must have been familiar with the property of lenses and mirrors to form erect and inverted images of the objects. There is reason to think that they employed them to effect apparition of their gods; and in some of the descriptions of the optical displays which hallowed their ancient temples, we recognise the transformations of the modern phantasmagoria.

MAGIC LANTERN. An optical machine employed to throw a magnified image of paintings upon glass or any transparent substance on a white screen in a darkened chamber. It has generally been devoted to the amusement of children, paintings of a ludicrous description being its usual accompaniment; but it may be employed with propriety to illustrate the principles of the sciences by a selection of suitable diagrams. The apartment in which the exhibition is made should be completely darkened, and no light allowed to escape from the lantern except what passes through the glasses. To increase the light, a concave reflector is frequently used, of such a curvature, that the candle is in its focus, so that the rays proceeding from it, fall parallel upon the glass next the candle. The glass sliders upon which the pictures are made, are generally of sufficient length to contain several sets of figures; the sliders being introduced by an opening, cut in each side of the tube containing the lenses. A section of this machine is shown below.

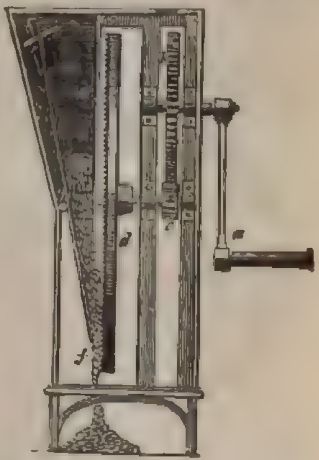
MAGNESIA. One of the primitive earths, having a metallic base called magnesium. It is a soft white powder; of specific gravity 2.3. It renders the syrup of violets, and the infusion of red cabbage, green; and reddens turmeric. It is infusible, except by the oxy-hydrogen blow-pipe. It has scarcely any taste, and no smell; is nearly insoluble in water, but absorbs that liquid with the production of heat. Its chief use is in medicine.

MAGNET, or LOADSTONE, is a ferruginous stone or ore of iron; it has the property of attracting iron, of pointing itself in a certain direction, and of communicating the same property to steel or iron.

MAHOGANY. The beautiful reddish brown coloured wood of which household furniture is now chiefly made. It is a native of the warmest parts of America and the West Indies. It thrives in most soils in the tropical climates, but varies in texture and grain according to the nature of the soil. On rocks it is of a smaller size, but very hard and weighty, of a close grain, and beautifully shaded; while the produce of the low and richer lands is observed to be

more light and porous, of a paler colour, and open grain; and that of mixed soils to hold a medium between both. The tree grows very tall and straight, and is usually four feet in diameter. On account of the difficulty of transporting the mahogany timber from the forests, when a tree is of great thickness they cut it into short logs, otherwise the great weight and bulk would be unmanageable with the restricted means available on the spot; and with the view of equalizing the burthen or draft of the cattle (oxen), the logs are long in proportion to their diminished thickness. The largest log ever cut in Honduras was of the following dimensions:—length, 17 feet; breadth, 57 inches; depth 64 inches; measuring 5,421 feet of plank, of 1 inch in thickness, and weighing upwards of 15 tons.

MAIZE, or INDIAN CORN being now cultivated to some extent in different parts of this country, we have given the engraving on the following page of a machine for husking the corn, or separating the grains from the ear, a process equivalent to that of thrashing employed for other grain. *a* is a crank handle or winch, which being turned, gives motion to a spur wheel *b*, and thereby causes a rapid revolution of the pinion *c*, on the shaft of which is fixed a large circular cast-iron plate *d*, the face of which is studded all over with very numerous cast-iron teeth or knobs; *e* is the hopper of the figure of a narrow inverted quadrangular pyramid; it has one of its sides movable, and capable of a very simple adjustment by turning as a lever upon a fulcrum at *g*, by which movement the aperture of discharge is enlarged or contracted; and it should be so regulated as only to admit of the central stalks of the cobs of the Indian corn to pass; these differ in size according to the fertility of the soil, the climate, and the treatment of the plant. At *h* there is a curved slot mortise through the side of the hopper, through which the stem of a thumb-screw passes from the outside into the movable plate, which is confined in any position at pleasure by half a turn of the screw. In America, where these machines are common, they are usually worked by one person turning the winch *a*, which gives very rapid revolutions to the plate *d*, whilst a boy drops one by one the cobs of Indian corn into the hopper, which causes each cob successively to spin round upon its axis, or stalk with great velocity, rubbing or knocking out the grain in its progress; and so effectual is the process, that a single turn of the winch *a* completely husks a large cob of maize.

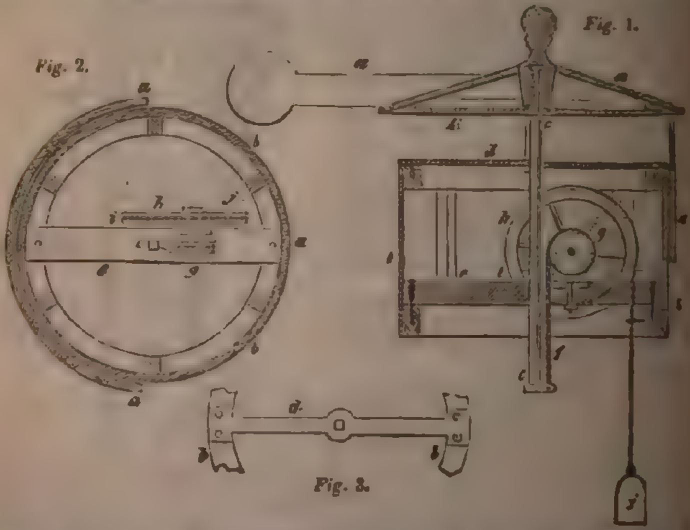


MALLET. A large kind of hammer, made of wood; they are of various forms, according to the kind of work to be performed by them

MALT. Grain which has become sweet from the conversion of its starch into sugar, by an incipient growth or germination artificially induced, called *malting*. In malting barley the usual method is to steep the grain in a sufficient quantity of water for two or three days, till it swells, becomes plump, somewhat tender, and tinges the water of a bright brown or reddish colour. The water being then drained away, the barley is spread about two feet thick upon a floor, where it heats spontaneously, and begins to grow by first shooting out the radicle. In this state the germination is stopped, by spreading it thinner, and turning it over once every four or five hours for two days; after which it is again made into a heat, and suffered to become sensibly hot to the hand, which usually takes place in from twenty to thirty hours; when it is spread out to cool, and afterwards dried upon the kiln, by a low and continuous heat, which renders it dry and crisp. The common malt-kiln is a square building, widening gradually within, from

the fire-place to a floor above, on which the malt is laid. It may be compared to an inverted pyramid, having a fire-place in its vertex, and its base covered by a floor, on which the malt is dried by the heat, and more or less smoke (according to the nature of the fuel and management of the fire), which ascends from the fire beneath. The floor is usually formed of tiles supported upon iron bars; the tiles have large holes made nearly through them from the lower side, and then very small holes pricked entirely through them. In some kilns webs of wire, covered with hair-cloth, are used instead of the perforated tiles. The fuel commonly used is either coke or stone coal; sometimes wood, and the hot-air that passes through the malt, has previously passed through the naked fire. An improvement in this respect has, however, been lately introduced, which, by means of a cast-iron tube, open externally to receive the air, and extended across the furnace and horizontal flue to acquire heat, thus delivers the air to the malt at an elevated temperature, and free from smoke, as well as other impurities. Distillers and brewers, whose buildings are so relatively situated, may thus lead the air cylinder for their malt kilns through the furnaces of their stills or boilers, and thus save the necessity of a distinct furnace for the malt, and a great portion of the cost of fuel.

An important improvement in malt kilns was introduced by Mr. Salmon, a maltster of Stokeferry, in Norfolk, in 1829, and for which he took out letters patent. This consists in admitting a portion of the hot-air from the flue into the part of the kiln above the malt, during the process of drying, instead of causing all the hot air to pass through the malt according to the customary practice. The object of this arrangement is to promote the evaporation, and to carry away the moist air instead of allowing it to be again condensed, and deposited on the surface of the malt. The grain floor of the kiln is made in the usual way, a portion of the heated air passing through the small perforations



therein; but the hot air is admitted into the upper part of the kiln through large openings furnished with tubes, or by small flues which extend higher than the surface of the malt on the floor, and thus a portion of the hot air is conveyed in a dry state to the space above the surface of the malt. The vapour that arises from malt when drying in the kiln, is discharged into the air through a hood or cowl, which turns round by means of a vane, so that the opening shall always be in the opposite direction to that from which the wind blows; but the aperture of the common cowl always remains of the same magnitude

therefore the draft through the fire admits of no accurate regulation; and lt-houses are not unfrequently set on fire in making high-dried malt, because fire is not perfectly manageable. Mr. Perkins, of Stanstead, in Hertford-re, has, however, invented a cap (for which he received an honorary medal n the Society of Arts), possessing all the advantages of the common cowl, with additional one of regulating the opening, and consequently the draft and ensity of the fire. It also entirely excludes wet when the wind is still and rain falls perpendicularly in showers, which is not effectually done with the mmon cowl, to the great injury of the malt lying on the floor, and the rusting the wire-work when that material is employed for the floor. *Fig.* 1 in the graving on p. 124, represents the turn-cap *a a* and the neck *b b* in section; *c c* quare iron bar or spindle, sliding through a square hole in the middle of the n plate or bar in *d*, and through another in the middle of the beam *e*; the p *a a* turns upon the upper cylindrical portion of this bar, and the bar itself supported and hangs entirely on the chain *f* attached to the pulley *g*, which is unted on a carriage on the beam *e*; on the same axis is a larger pulley *h* with chain attached to it at *i*, and from which a chain and weight *j* hangs, sufficient balance the weight of the sliding bar *c*, and turn-cap *a a*. By raising the weight he cap is lowered and finally shut; and on lowering the weight the cap is sed quite up, or held at any intermediate height. *Fig.* 2 is a section of the k between the bars *d* and *e*. *Fig.* 3 is a top view of the bar *d*, showing the e through which the spindle passes; *k*, *Fig.* 3, is a similar iron bar across the p *a a*. The chain *f* should be attached quite close to the bar *c c*, to lessen tendency to lean on one side. Malt may be dried upon the same kilns as e used for drying grain generally; see the article KILNS.

MALTHA. The mineral tallow of Kirwan, said to be found on the coast of land, also on the lake Baikal, in Siberia. It resembles wax, and has hence en denominated sea-wax. It is a solid substance, spec. grav. 0.77, white, brittle, ns paper like oil, melts with a moderate heat, and burns with a blue flame d much smoke; dissolves readily in oil, and imperfectly in hot alcohol. The m *maltha* was likewise applied by the ancients to a species of cement, of ich there were two kinds, native and factitious; one of the latter consisted pitch, wax, plaster, and grease; another (which, it is said, they used in their educts) was made of lime slacked in wine, and incorporated with melted ch and fresh figs.

MANDREL is the name given to a kind of pulley, forming an important t of a lathe; there are various kinds,—see TURNING.

MANGANESE, is a metal of a dull whitish colour, but soon changes to a k grey by exposure to the air. It is hard, brittle, rough in its fracture; not verizable, but falls to powder when broken to pieces by spontaneous oxida-n. It is so difficult of fusion, that no heat yet exhibited has caused it to into masses of any considerable magnitude. Concentrated sulphuric acid cks manganese, at the same time that hydrogen gas is disengaged. Nitric d dissolves it with effervescence, and the escape of nitrous gas. A spongy, k, and friable matter remains, which is a carburet of iron. The oxide is readily soluble in nitrous acid. Manganese is dissolved in the usual nner by muriatic acid. In the dry way, the oxide of manganese combines h such earths and saline substances as are capable of undergoing fusion in a ng heat. Manganese melts readily with most of the other metals, but cts mercury. Gold and iron are rendered more fusible by a due admixture manganese, and the latter metal is rendered more ductile. Copper becomes fusible, and is rendered whiter, but of a colour subject to tarnish. The ore manganese, known in Derbyshire by the name of *black wadd*, is remarkable its spontaneous inflammation when thoroughly dried with oil. Manganese merly used by the glass makers and potters, but since the discovery of rine, its application in the art of bleaching has much extended its useful-s. See BLEACHING.

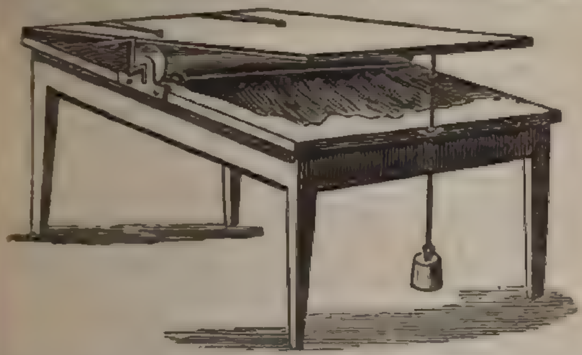
MANGLE. A domestic machine of great utility, employed in smoothening n, as a substitute for the heated irons extensively used for the same purpose. In the common mangle, as most of our readers well know, the linen or other

articles to be mangled, are wrapped round wooden rollers, which are p
upon a solid level bed or floor, and upon the rollers is placed a large oblong
which is filled with stones, or other heavy substances, in order that they
press with great force upon the rollers, while the box is moved backward
forwards upon them, by means of a handle attached to an upper roller or
lass, to which straps from each end of the moving box are attached. By
machine, the operation of mangling is very well done, but the labour is ex
sive on account of the necessity of frequently arresting and changing the m
of the heavy box. In China, mangling is performed in the most perfect m
ner by a machine of the same kind as our common mangle, but far sim
A concavity is formed in the floor of the apartment, of a hard and pol

wood, into which is placed a roller, with the cloth intended to be mangled, and
it. A heavy stone, (so shaped as to rest on either end while the oper
examines his work,) is then glided on the roller, and its elevations alternat
pressed by his feet, so that the article shall receive an equal pressure on ev
part of it. The man supports himself by bamboos placed in the floor for t
purpose, as represented by the above engraving, and after a labour of four
five minutes, the work is admirably finished.

Another extremely simple machine, delineated in the engraving on p. 127,
been applied with good effect, by Mr. Pitcher, for the purpose of mangling lin
It consists of a roller about 4 inches in diameter, and 30 inches long, with a pi
of the thick woollen cloth used for ironing, firmly fixed thereon. The roller
turned round by means of a winch, and has its bearings at the ends in two st
iron plates, screwed to the sides of the table. Upon the roller rests a bo
of the length and width of the table, secured to it at one end by hinges,
has at the other end a weight suspended to it, the pressure of which, upon tu
ing the winch, winds the woollen cloth, and the damp linen articles laid up
it, so tight upon the roller, that by continuing the motion, the linen become
smooth as upon the common unwieldy mangle. The roller rests upon the ta

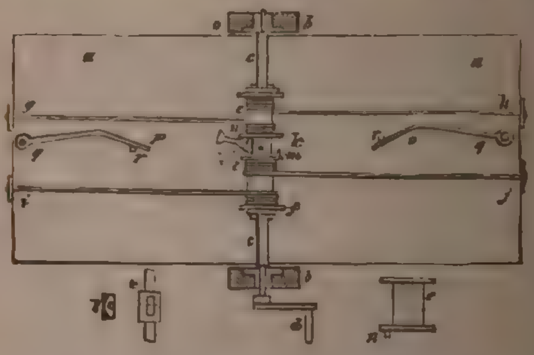
the iron plates allow it to rise and fall, according to the quantity of cloths ...ped round it. This mangle, when not in use, serves the purpose of a ...on table, by merely unshipping the roller; this circumstance, and the ...ty and cheapness with which it may be constructed by any common work... are great recommendations to its employment by such as cannot afford, ...o have not adequate occasion for, the more complex and perfect machines.



...n important improvement in the construction of the common mangle, first ...ribed, was effected about thirty years ago by Mr. Baker, of Fore-street, ...don, by which the otherwise unwieldy heavy box was moved with great facility ...wards and forwards, by a continuous motion of the handle in one direc...; and by the addition of a fly wheel to equalize the motion, a great amount ...uscular exertion is saved to the individual working the machine. The ...n employed by Mr. Baker is highly ingenious and interesting; and although ... been superseded by others of a simpler and more efficient kind, we can... pass it by without a brief notice of its construction. It consists of a wheel, ...g a series of teeth or pins on the outside of the periphery, and another ... of similar teeth or pins upon the inside of the periphery. In these teeth ...olving pinion works, traversing from the inside to the outside of the wheel, ... contrary way, during the reversing of the motion, instead of confining ...nion to one course, as in working an ordinary cog wheel. To enable the ... to do that, a portion of the periphery of the wheel is cut away, through ... the pinion passes, by rolling round from the outside into the inside, then ...d the latter again to the former; the axis of the pinion has therefore a ... or play to the extent of the thickness of the rim of the wheel, between ...ner and the outer cogs. From the foregoing, it is evident that by the ...ued action of the pinion, it turns the wheel round nearly a revolution one ... and then through the same space the contrary way; and as the two ends ... loaded box are attached by chains to the reciprocating wheel, it is ... to traverse backward and forward. This traversing motion, by the revolu... a pinion, was subsequently improved by Mr. Elisha Peechey, and applied ...ery convenient mangle, for a model of which Mr. Peechey was awarded ...ver medal of the Society of Arts. This mangle had what may be called ...er and a lower rack inside a slot, which was made to traverse by the revo... of a pinion, as in Baker's patent mangle. The pinion in this case has a ...ary axis, and the bar in which the racks are formed has a pin in its ...side, which sliding between grooves in the plummer blocks, keeps it ... against the pinion when the upper rack is operated upon; another pin ... on the lower side of the bar, which in like manner keeps it in contact ...e pinion when the latter is operating upon the lower side, the bar con... the racks thus always accommodating itself to the continuous motion ... pinion, which thereby impels it alternately in opposite directions. A ... of this kind, in which several important improvements have been in...d, is manufactured by Mr. Christie of Sheffield, in a style of great

excellence, and at a very moderate cost. Instead of the top and bottom this mangle is provided with a stout metallic bar, with a row of pegs al middle of one side of it; and parallel with the line of these pegs there is projecting flange, designed to confine a pinion in its hold upon the pegs rack traverses backwards and forwards, by acting successively on each the series of pins; and the rack is so balanced by weighted levers, that pinion passes round the endmost peg, at either end the rack is alternately and depressed. For a particular description of this machine, see *Reg Arts*, Vol. I. New Series, p. 168.

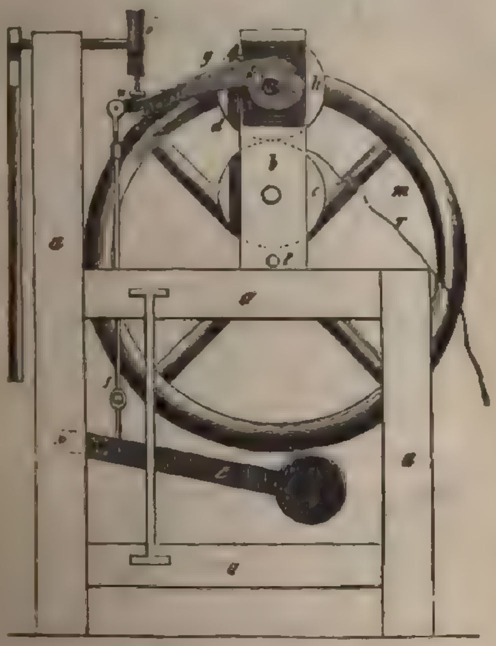
A new and very simple method of producing the alternate motion mangle-box, by the continuous motion of the handle in one direction, in by John Thurrel, was lately communicated to the Society of Arts, a p which is represented in the subjoined engraving. *a a* is the mangle-b parts of the frame which support the axis *c c*; *d* the cranked handle, *e* and barrels loose on the axis *c c*; to the barrel *e* are fastened two cords, one of after making several coils round the barrel, passes from its *under* side eye *h*, where it is secured; while the other, after having in like manner round the barrel, is also delivered from its under side to the eye *g*. barrel *f* are also fastened two cords, which being delivered from the upp of the barrel are respectively fixed in the eyes *i* and *j*. The part *k* of the between the barrels, is made square, and is cut out longitudinally to recei lever *l*, which is secured in its place by a pin, but so as to allow of motion between the two barrels; each of these barrels has a stud *m* and placed that the lever may be shifted to engage either of them, and consequ to oblige that barrel with which it may be engaged to revolve, togethe the axis; *o* and *p* are two alternating irons, each with an eye at one through which a pin *q* passes, in order to fasten them to the mangle box; height above the box is such as to allow them just to clear the axis when under it, and the motion of each is limited, but on opposite sides, adjusting pins *r r*.



The figure represents the lever *l* as engaged with the stud *n*, and conse as being fixed in the barrel *e*; now if the barrel is turned so as to wind cord *h*, the cord *g* will proportionably unwind, and the mangle-box will from left to right till the end *l* of the lever comes in contact with the alter iron at the point *o*. By continuing to turn the handle, the end of the slides from *o* to the end of the iron, and is brought into the position sho dotted lines; the stud *n* is consequently disengaged, and the barrel *e* b loose; at the same time the lever engages the stud *m*, and fixes the b The handle being still turned in the same direction as at first, begins to the cord *i*, and thus makes the box begin to move from right to left, the at the same time unwinding proportionally. When the left hand alte iron has begun to come under the axle, the end of the lever will touch

will slide along it to the point of the angle, and in doing so will bring it to the position shown in the figure, the barrel *e* being now fixed, and the barrel *f* being loose. Thus is accomplished the production of an alternating motion of the box, by continuing to turn the handle always in the same direction. The back of the lever *l* is bevelled off, so that if the handle is turned in a wrong direction, it passes between the studs *m* and *n*, and not engaging either barrel produces no motion of the mangle-box. *Fig.* 2 is one of the barrels separated; and *Fig.* 3 the square middle part of the axis, showing the slit in which the lever traverses.

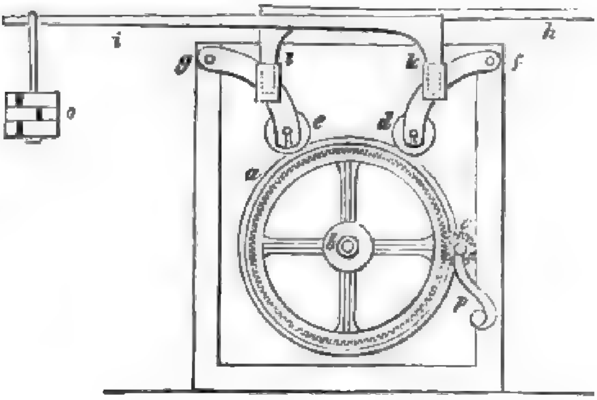
In 1823, a patent was taken out by Mr. Snowdon for an erect or vertical mangle, by which it was intended to obviate an objection sometimes made to the common horizontal mangles that we have been describing; namely, the great space they occupy. Several patents have indeed been taken out for mangles of the vertical kind; but, for reasons that we are not acquainted with, have not been much patronised by public adoption. The following invention was patented in 1828, by Mr. Samuel Wilkinson, of Holbeck, in Yorkshire, but, as stated in the specification, the machines so constructed were to be called "Bellman's Cabinet Mangles." The annexed figure affords a side view of the principal parts of the machine, those which are omitted being left out for the better elucidation of the more essential parts. *a a* represents one side of the frame, *b* one of the cheeks supporting the lower roller *c*; the upper roller *d* rests upon the lower one. Pressure is given by a weighted lever *e*, suspended by the rod *f* from another lever *g*, which turns upon a fulcrum at *h*, and has a



piece of hardened steel *k* dovetailed into it, against which the axis of *d* works. The lower roller *c* has a wheel on its axis, turned by a pinion on the axis *l* of the fly wheel *m*, and the fly wheel is made to revolve by a handle on one of its arms. To raise the upper roller to place under it the articles to be mangled, the arm *g* is connected to a similar arm on the opposite side by a cross bar *n*,

suspended by a chain from the wheel *o*, which being turned by
elevates the arm *g*, and with it the upper roller *d*. The line *r* n
sents the situation of the mangling cloth. The patentee is silent i
cation as to the mode of working the machine, whether by cc
reciprocating action. Some articles will require to be passed unde
more than once, and we can discover no method in the present
doing this, but by reversing the motion, which will require attention
of the mangler, who must watch until the goods are nearly past the
then reverse the motion; whilst the common mangle performs tl
If the mangling cloth were an endless web passing over other roller
motion alone would be required; but the patentee does not state i
cation that he uses any such arrangement. The machine seems c
obtain a considerable degree of pressure in a convenient manner.

The sketch below is taken from a small model of a mangle th
bited amongst others at the National Repository, invented by M
and Webster, of Thornhill, in Yorkshire. *a* is a drum or cylinder
of which, and on the same axis is fixed the toothed wheel *b*, which
the pinion *c* by the revolution of the winch *p*. *d* and *e* are two r
which the cloth to be mangled is wrapped; these rollers are pl
curved arms shown, which turn upon centre pins at *f g*; *h* and *i* ar
bended ends of which fit into *sockets* in the curved arms; (in the
levers were *rivetted* to the arms, which the editor considered to be i
o o are weights suspended to the levers to give the pressure, whicl
creased or diminished at pleasure, either by altering the actual qua
weights or changing their situation on the levers. In order to
clothes from either of the rollers, or to put others on, the weights m



off the lever, the lever must be lifted out of its socket or be lif
the curved arm which turns upon its end, and be thrown back toge
some slight modifications (such as an easy mode of removing the lc
levers, &c.) this compact mangle may be made very convenient and

MANNA. A white sweet juice, which oozes from the trunk, b
leaves, of several kinds of trees; but the ash, the larch, and the
it in the largest quantities. Sicily and Calabria, are the countries f
it is chiefly obtained; where it flows naturally from the ash, and at
to its sides in the form of white transparent drops; but the extrac
juice is facilitated by incisions made in the tree during summer.
strong, and its taste sweetish, and slightly nauseous. Water diss
or cold. If it be boiled with lime, clarified with white of egg,
trated by evaporation, it affords crystals of sugar. This substanc
basis of many purgative medicines.

MANOMETER, an instrument for measuring the rarefaction and condensation of elastic fluids, but especially that of the atmosphere. It differs from the barometer which shows only the weight of the superincumbent column of air; whereas the manometer shows the density, which depends on the combined effect of weight and the action of heat. It is sometimes called manoscope. Among the various contrivances of this kind may be mentioned that of the Hon. Robert Boyle, which he calls a statical barometer; which consists of a bubble of thin glass about the size of an orange, which being counterpoised in an accurate pair of scales, rises and sinks with the alterations of the atmosphere. This instrument, however, does not show the cause of the difference of density in the atmosphere, whether it be from a change of its own weight, or its temperature, or both. The manometer constructed by Mr. Ramsden, and used by Capt. Phipps, in his voyage to the North Pole, was composed of a tube of small bore with a ball at the end; the barometer being 29.7, a small quantity of quicksilver was put into the tube, to take off the communication between the external air and that confined in the ball, and the part of the tube below this quicksilver. A scale is placed on the side of the tube, which marks the degrees of dilatation arising from the increase of heat in this state of the weight of the air, and has the same graduation as that of Fahrenheit's thermometer, the point of freezing being marked 32°. In this state, therefore, it will shew the degrees of heat in the same manner as a thermometer. But if the air becomes lighter, the bubble inclosed in the ball being less compressed, will dilate itself, and take up a space as much larger as the compressing force is less; therefore the changes arising from the increase of heat will be proportionably larger, and the instrument will show the differences in the density of the air, arising from the changes in its weight and heat. Mr. Ramsden found that a heat equal to that of boiling water, increased the magnitude of the air from what it was at the freezing point by $\frac{4\,14}{1000}$ of the whole. Hence it follows, that the ball and part of the tube below the beginning of the scale, is of a magnitude equal to almost 414 degrees of the scale. If the height of both the manometer and thermometer be given, the height of the barometer may be determined also.

MAPLE. From the juice of this tree obtained by tapping, the Americans prepare a sugar, and the Highlanders, it is said, an agreeable wine.

MARANTA, or *Indian Arrow Root*. From this root, washed, pounded, and macerated in water, is obtained the fashionable starch called arrow-root, much used for infant and invalid food.

MARBLE, a fine kind of lime-stone, (a carbonate of lime;) it is found in extensive masses in most parts of the world. It occurs in beds in granite, gneiss, &c., rarely in secondary rocks, and is found in all the great ranges of primitive rocks in Europe. Its hard, compact texture, semi-transparency and lustre, when polished, has made it a great favourite in architecture and house building. The finer kinds, especially those used by the statuary are chiefly obtained from Italy; but there are a great variety of beautiful marbles in Great Britain and Ireland. See *Jameson's Mineralogy*, Vol. II. For an improved method of sawing marble and other hard stone, see SAWING. An artificial marble is frequently made from plaster of Paris, quicklime, salt, ox-blood, pieces of glass, and stones of different colours. These are beaten to an impalpable powder, and mixed up to the consistency of paste with beer or milk. When thoroughly dried in the form which is intended to be given to it, it is rubbed with sand paper and polished with emery and oil. Mr. Wilson's process for making artificial stone chimney pieces, is described under the article STONE.

MARBLING of books. See BOOKBINDING.

MARINE ACID. See ACID MURIATIC.

MARINER'S COMPASS. See COMPASS.

MARL. An earth, of which there are three principal kinds, the calcareous, the argillaceous, and the siliceous; according as the lime, the clay, and the silex abound in them.

MARLINE-SPIKE. An iron tool, tapering to a point, used to separate the strands of a rope, in order to introduce those of another, when they are to be spliced, or joined evenly, without knotting.

MARQUETRY. A kind of inlaid work, composed of a tasteful variety of fine woods, of different shades and colours, glued or fastened in thin slices on a solid ground; the work is not unfrequently enriched with silver, brass, tortoiseshell, ivory, and other beautiful substances; and the pieces, duly prepared beforehand, are successively laid together according to a design or drawing.

MASONRY. The art of hewing and preparing stones of their due proportions and figure, and of joining them together, in building houses, and other works.

MASSICOT. The yellow oxide of lead. See LEAD, and PAINTING.

MAST. A long round piece of timber, raised perpendicularly on the keel of a ship, upon which are attached the yards, the sails, and the rigging. A mast, according to its length, is either formed of one single piece, which is called a pole mast, or composed of several pieces joined together, each of which retains the name of mast separately. A *lower mast* being the lowest, is accordingly so called; the foot of it rests on a block of timber called the step, which is fixed on the keelson. A *top mast* is raised at the head or top of the lower mast, through a cap, and supported by trestle trees, (See the article FID.) The *top-gallant mast*, is a smaller mast than the preceding, and is secured to its head in the same manner. The *top-gallant royal mast* is a yet smaller mast sometimes raised above the last mentioned; but in some ships it denotes a continuation of the top-gallant mast, above the rigging: it is then called a *pole* top-gallant, to distinguish it from a *stump* top-gallant mast, which terminates just above the rigging. The *main-mast* is the largest mast in a ship, and stands nearly in the middle, between the stem and the stern. The *fore-mast* is that which stands near the stem, and is next in size to the main-mast. The *mizen-mast* is the smallest mast, and stands about half way between the main mast and the stern. *Made-mast* is a term applied to a mast composed of several pieces of timber in contradistinction to those made of a single stick. *Rough-mast*, denotes a spar fit for making a mast. Besides the parts already mentioned, in the construction of masts, with respect to their length, the lower masts of the largest ships are always made of several pieces of timber firmly united, by stout iron hoops. As these are generally the most substantial parts of various tiers, a mast thus formed is esteemed stronger than one consisting of only a single timber, the strength of which, by internal defects, may be considerably impaired. Attempts were made some years ago to introduce hollow masts, the invention of Mr. George Smart, of Westminster Bridge; and they were, we believe, partially adopted for small vessels; such masts, from their cylindrical figure, being stronger than solid masts, containing a similar mass or weight of materials. Sir Robert Seppings has likewise distinguished himself, amongst his other improvements in ship building, in the construction of masts, for which he took out a patent; the specification of which informs us that, for ships of the line, frigates, and large merchantmen, whose masts are more than 33 inches in diameter, they are to be composed of twelve principal pieces, in the following manner. Four pieces of small square balk timber are to be united diagonally, so as to form a hollow square in the centre. Externally on each of these four pieces are to be tree-nailed two additional pieces. The twelve pieces thus united, are now to have their angular edges cut away, and planed down, so as to bring the whole to a circular figure, when an iron hoop is to be placed round them, and the angular spaces filled up with slips of wood. In connecting the pieces of timber so as to form the required length of mast, bars of iron are to be inserted longitudinally into mortices made in both to receive them; and the several pieces are to cross each other or "break-joint." In constructing the masts for smaller vessels than before mentioned, only eight or four balk timbers are to be employed, (according to their dimensions,) which are to be connected longitudinally and transversely in a similar manner to that described. Hollow masts so formed, are not only much stronger than when solid, but they effect a great economy in the cost, in the facility of making, and of transportation.

A patent for "Improvements in Masting Vessels," was taken out in 1826.

by Mr. Thomas Guppy, of Bristol; from the enrolled specification of which, we collect the following information, exhibiting the principal features of the invention. Instead of a single pole fixed in the keel, in nearly a vertical position, constituting what is called a mast, the patentee employs two poles or spars, the heels of which are fixed on to the opposite extremities of the beam of a vessel, and likewise to the sides; the poles are then so inclined to one another, as to be connected at their upper ends, and thus form with the line of the deck an isosceles triangle; this is the outline of the construction as applied to sloops, or ordinary fore and aft rigged vessels. For square rigged or larger vessels, the poles are not joined at their upper extremities, but at several feet below it, where they cross one another, presenting the figure of an open pair of shears. In all cases, however, the lower ends of the poles are fastened in the situation and in the manner before-mentioned. Thus situated, they are invested with the important property or capability of being lowered forward or aft, as the occasion may render desirable, by the employment of hinge joints at their extremities, close to the deck. At the junction of the poles above, suitable arrangements are made for the fixing of top masts therein, which are provided with gear for that purpose, as well as for the *masting of other vessels*; for loading or unloading vessels; and for those other purposes for which sheers are usually employed on board of ships. The principal rigging for these "double pole masts" are the fore and aft stays, the ordinary side shrouds being comparatively unimportant, except for the purpose of going aloft. At *Fig.* 1 in the annexed engraving *a a* are the two poles, having joints at *b b*, from whence proceeds a strong iron band which clasps the opposite ends of the beam *c*, which underneath diverges into two iron straps, that are bolted to the side of the vessel. This arrangement is explained by *Fig.* 4, which exhibits a perspective side view of the iron work which connects the poles to the vessel, with a portion of the beam, and a pole *c c* is the beam, with the iron band bolted to it, and showing the straps *d d* that are secured to the sides of the vessel, and are turned up flatways towards them. The poles are connected together at *e* by a stout iron band, by scarfing and crossing each other, as shown by the separate *Fig.* 2 in perspective; *f* is the top, where the upper ends of the poles are strongly secured to one another by straps and bolts; *g* is the lower end of the top-mast, which passes through a hole adapted to it in the top, with its heel resting upon an iron projection, which is of one piece with the band *e*. For sloops and fore and aft rigged vessels generally, the poles *a a* terminate at their junction, and are united by scarfing, previous to putting on the strong iron band. The mode of scarfing the patentee leaves to the genius of the mast maker, but at the same time points out one mode which he most approves of, and which, perhaps, cannot be much excelled. This mode is shown in the perspective sketch, *Fig.* 3 Connected to the band which unites the poles together, are fixed long iron links *i i*, for hooking in, or *seizing* the shrouds to.

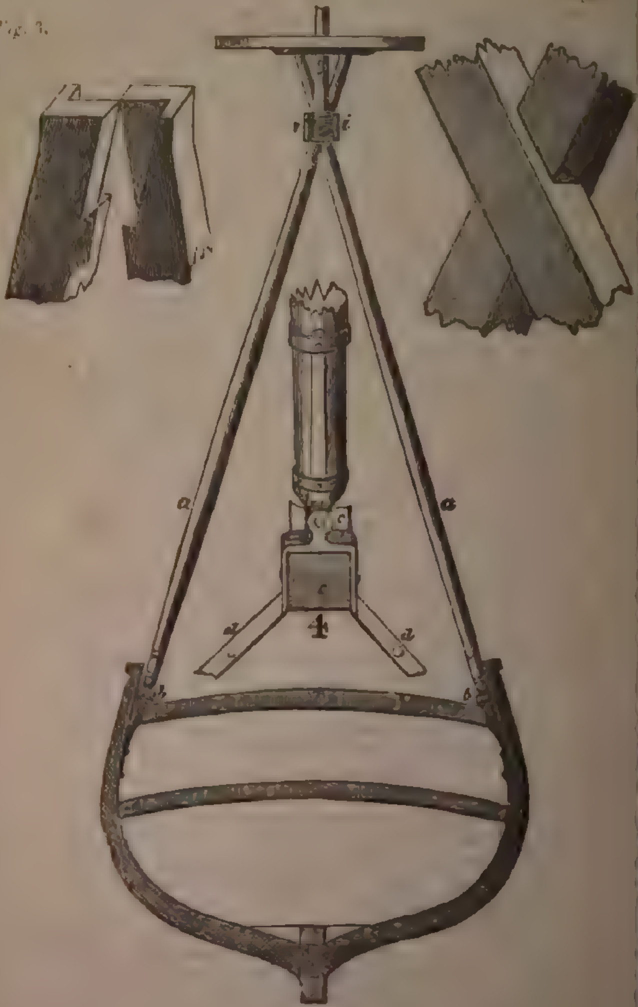
A few years ago Lieut. Molyneux Shuldham, R.N. took out a patent for *revolving masts*, the enrolled specification of which exhibits in sixty-five diagrams and designs, numerous modifications and applications of the principle to various descriptions of inland as well as sea-going vessels. As our space will only admit of a brief outline of the nature of the invention, we must refer the reader who may be solicitous for the details, to the inrolled document in Chancery-lane, and to some beautiful models illustrative of the inventions (constructed by the talented inventor's own hands), exhibited at the National Museum of the Mechanical Arts, in Leicester-square, London. The mast instead of being, as in ordinary vessels, a fixture, is herein made to revolve upon its axis, or turn horizontally upon its heel, carrying with it the sails, yards, and other rigging attached to it, and thereby instantly changes the direction of the vessel's motion. The power required to perform these evolutions may be the wind or manual labour, or both conjointly. As the action of the wind will naturally tend to produce the desired effect in both cases, whatever manual force may be required to assist the operation must be very little indeed; that is to say, according to modern phraseology, the maximum of effect is produced by a minimum of labour. It will be evident from this arrangement of the machi-

nery of a ship, that fewer hands will be required to work it, that the ru[...] rigging may be much simplified and curtailed, and the wear and tear [...] reduced. These improvements are considered applicable to open boats, [...] boats, and small craft in general; to vessels employed in inland navig[...] coasting vessels, and particularly those navigating intricate channels [...]

Fig. 3.

Fig. 1.

Fig. 2.



rivers. But Mr Shuldham does not consider them applicable to vess[...] war and vessels of small tonnage, that carry lumber in their decks, owi[...] the room required for the revolving bases of the masts. The masts are vari[...] supported, according to the tonnage of the vessels: in decked boats and [...]

vessels, an iron or wooden pivot is sufficient; in larger vessels anti-friction rollers are fixed to the revolving base, which work between two annular plates, secured to the gunwhales and deck.

MASTIC. A resinous substance in the form of tears, of a pale yellow colour, and farinaceous appearance; having little smell and a bitter taste. It flows naturally from the tree; but this process is accelerated by making incisions in the bark. It is extensively used in the composition of varnishes. Pure alcohol and oil of turpentine dissolve it chiefly, the residue partaking of the nature of caoutchouc. An agreeable odour is given out by mastic when heated; it is, in consequence, much used in fumigations, and in the fabrication of pastiles.

MATTER is generally understood to mean that solid, inert, divisible substance, accessible to the senses, of which all bodies in the universe are formed. Dr. Woodward was of opinion that matter is originally, and is really, various; Sir Isaac Newton, however, considered matter as homogenous in all bodies, and the difference of form to be owing to a varied arrangement of the corpuscles of one homogenous substance. That matter is one and the same thing in all bodies, and that all the varieties we observe arises from the various shapes it puts on, seems very probable, from a general observation of nature in the generation and destruction of bodies. Thus water rarefied by heat becomes vapour, a great collection of which forms clouds; these condensed, descend in hail or rain; part of this collected on the earth constitutes rivers; another part combines with earths or metallic matter, forming minerals and crystallized salts; another enters the roots of plants, and expands itself into all the wonderful variety and magnificence of the vegetable creation. From the vegetable matter animals derive their support and means of reproduction; and however these mineral, vegetable, and animal productions may change, the same individual matter is never destroyed, but reappears under other combinations.

MATRIX. The stone in which metallic ores are found enveloped; the same term is applied by type-founders to the metallic mould in which the letters are cast.

MEAD. A wine prepared from honey; a quantity of good honey, with rather more than its weight of water is to be boiled, scummed, and evaporated until it is of a consistence that will float an egg; the liquor is then to be strained and poured into a barrel; this barrel, which ought to be nearly full, must be exposed to a heat as equable as possible, from 75° to 90° Fahr., keeping the bung-hole slightly covered but not closed. The spirituous fermentation will take, and continue during two or three months, according to the heat. During this fermentation, the barrel is to be occasionally filled up, with more of the liquor of honey (previously saved for that purpose) to replace that which flows out in froth. When the fermentation ceases and the liquor has become vinous, the barrel should then be closed and stored in a cool cellar. In twelve months it is fit for bottling.

MEAL. The flour and bran of corn in the mixed state; they proceed from the mill before they are separated by a bolter or dressing machine.

MEASURE. A quantity assumed at pleasure, and considered as unity, or one, to which the ratio of other quantities being determined, their relative magnitude, both to the assumed unit, and to each other, will be known. The quantity assumed as unity, is called the measuring unit. Thus, to measure any proposed line, we assume a line of an inch, a foot, a yard, &c., as the measuring unit, suppose this to be an inch; then as many times as it is contained in the proposed line, so many inches will that line be in length. If the proposed line be less than the measuring unit, whatever part that line is of the measuring unit, the same part of an inch will the measure of that line be, and the like of feet, yards, &c. To measure a superfices, a square whose sides are an inch, a foot, a yard, &c. is the measuring unit; and as many times as this is contained in, or contains the given superfices, such will be the measure of that superfices, as was shown in the line. To measure a solid, a cube whose lineal side is an inch, a foot, a yard, &c., is assumed as the measuring unit; and as many times as this unit is contained in, or contains the given solid, so many cubic inches

feet, yard, &c., or parts of one of them, will the proposed solid be. Th measure for lines or length is termed *lineal* or long measure: that for surfac *superficial* measure; and that for solids or capacities, cubic or solid measure.

In 1825 a Bill was passed through Parliament for altering weights and me sures previously in use, the preamble of which states, "whereas it is necessar for the security of commerce, and for the good of the community, that weigh and measures should be just and uniform: and whereas notwithstanding it provided by the Great Charter, that there shall be but one measure and o weight throughout the realm, and by the treaty of union between England an Scotland, that the same weights and measures should be used throughout Gre Britain, as were then established in England; yet different weights and measure some larger, and some less, are still in use in various places throughout the Unite Kingdom of Great Britain and Ireland, and *the true measure of the present standa is not verily known*, which is the cause of great confusion and of manifest fraud for the remedy and prevention of those evils for the future, and to the end th certain standards of weights and measures should be established throughout t United Kingdom of Great Britain and Ireland, the new standards are denom nated *imperial*, and the rationale of the system by which they have been dete mined is thus explained. Take a pendulum which will vibrate seconds London, on a level of the sea, in a vacuum: divide all that part thereof whi lies between the axis of suspension and the centre of oscillation into 39·13 equal parts; then will ten thousand of those parts be an imperial inch; whereof make a foot, and 36 whereof make a yard.

The *standard yard* is determined to be, "that distance between the centres the two points in the gold studs in the straight brass rod, now in the custody the clerk of the House of Commons, wherein the words and figures 'Standa Yard, 1760,' are engraved, which is declared to be the genuine standard of th measure of length called a yard:" and as the expansibility of the metal wou cause some variation in the length of the rod in different degrees of tempe ture, the act determines that the brass rod in question shall be of the tempe ture of 62° Fahr. The measure is to be denominated the "Imperial Standa Yard," and to be *the only standard whereby all other measures of lineal extensi shall be computed.* Thus the foot, the inch, the pole, the furlong, and the mil shall bear the same proportion to the imperial standard yard as they ha hitherto borne to the yard measure in general use. And should it happen th the aforesaid brass rod of 1760 be lost, defaced, or destroyed, a reference to t invariable natural standard afforded by the pendulum before mentioned, w enable it to be restored with the utmost exactness.

The standard gallon is determined by the act to be such measure as sh contain 10 lbs. avoirdupois weight, of distilled water, weighed in air, at t temperature of 62°. of Fahr., the barometer being at 30 inches, to be used well for wine, beer, ale, spirits, and all sorts of liquids, as for dry goods, n measured by heaped measure; and that all other measures shall be taken parts or multiples of the said imperial standard gallon, the quart being t fourth part of such gallon, and the pint one-eighth part; two such gallo making a peck, eight such gallons a bushel, and eight such bushels a quarter corn, or other dry goods not measured by heaped measure."

Heaped measure.—"That the standard measure of capacity for coals, li culm, fish, potatoes, or fruit, and all other goods, and things commonly sold heaped measure, shall be the aforesaid bushel, containing 80 lbs. avoirdup of water, as aforesaid, the same being made round with a plane and ev bottom, and being 19½ inches from outside to outside of such standard measu as aforesaid:" and goods thus sold by heaped measure shall be heaped "in t form of a cone, such cone to be of the height of at least six inches, the outs of the bushel to be the extremity of the base of such cone;" three such bush shall be a sack, and twelve such sacks shall be a chaldron.

Stricken measure.—The last-mentioned goods may be sold either by the hea measure or by the standard weight (see the article WEIGHT); but for all ot kind of goods not usually sold by heaped measure, which may be sold or agreed by measure, the same standard measure shall be used, but it shall not be heap

but stricken with a round stick or roller, straight, and of the same diameter from end to end.

The following tables, which are in accordance with the new standard, it will be proper to insert in this place:—

Measures of Length.

12	inches are equal to		1 foot.
3	feet	=	1 yard.
5½	yards	=	1 rod or pole.
40	poles	=	1 furlong.
8	furlongs	=	1 mile.
$69\frac{1}{13}$	miles	=	1 degree of a great circle of the earth.

An inch is the smallest lineal measure to which a name is given, but mechanics subdivide it generally into eighths and sixteenths; measures or "rules" are however constructed by the rule-makers with every possible variety of subdivisions or scales of the parts of an inch that can be required by artificers, engineers, and scientific persons.

The following particular measures of length are in general use:—

1 nail	=	2¼ inches	used for measuring cloth.
1 quarter	=	4 nails	
1 yard	=	4 quarters	
1 ell	=	5 quarters	
1 hand	=	4 inches . . .	used for measuring the height of horses.
1 fathom	=	6 feet	used in measuring depths.
1 link	=	$7\frac{92}{100}$ inches	used in measuring land, to facilitate computation of the contents, 10 square chains being equal to an acre.
1 chain	=	100 links	

Measures of Surface.

144 square inches are equal to		1 square foot.
9 square feet	=	1 square yard.
30¼ square yards	=	1 perch or rod.
40 perches	=	1 rood.
4 roods or 160 perches	=	1 acre.
640 acres	=	1 square mile.

Measures of Solidity.

1728 cubic inches	=	1 cubic foot.
27 cubic feet	=	1 cubic yard.

Imperial Measures of Capacity.

4 gills	=	1 pint	=	34⅔	cubic inches nearly.
2 pints	=	1 quart	=	69⅓	"
4 quarts	=	1 gallon	=	277¼	"
2 gallons	=	1 peck	=	554½	"
8 gallons	=	1 bushel	=	2218⅕	"
8 bushels	=	1 quarter	=	10¼	cubic feet nearly.
5 quarters	=	1 load	=	51⅓	"

The foregoing measures are used for all liquids, and for all dry goods, except culm, lime, fish, potatoes, fruit, and other goods commonly sold by heaped measure.

2 gallons	=	1 peck	=	704	cubic inches nearly.
8 gallons	=	1 bushel	=	2815½	"
3 bushels	=	1 sack	=	$4\frac{89}{100}$	cubic feet nearly.

A knowledge of the comparative value of English and French measures being indispensable to every scientific reader, we add the following calculation of them by Dr. Duncan, jun. :—

1. *French Measures of Length, the metre being at 32°, and the foot at 62°.*

Millimetre	=	.03937	English inches
Centimetre	=	.39371	"
Decimetre	=	3.93710	"
Metre	=	39.37100	"
Decametre	=	393.71000	"
Hecatometre	=	3937.10000	"
Kilometre	=	39371.00000	"
Myriometre	=	393710.00000	"

2. *French Measures of Capacity.*

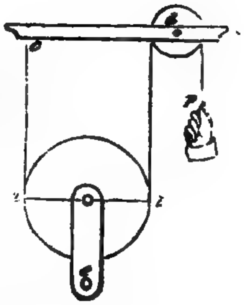
Millilitre	=	.06103	English cubic inches.
Centilitre	=	.61028	"
Decilitre	=	6.10280	"
Litre	=	61.02800	"
Decalitre	=	610.28000	"
Hecatolitre	=	6102.80000	"
Kilolitre	=	61028.00000	"
Myriolitre	=	610280.00000	"

For the comparative value of English and French measures of weight, see Weight.

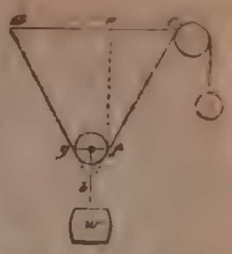
MECHANICS is a science which treats generally of the action of forces on solid bodies, and the construction and use of machinery. When forces acting upon a body in different directions produce equilibrium, it is investigated under the head of Statics; but when the acting forces are so applied as to produce motion, it constitutes a case in Dynamics, which see.

MECHANIC POWERS are those simple machines or elements that enter into the construction of the various parts of machinery: they are usually considered to be six in number; viz. the lever, the wheel and axle, the pulley, the inclined plane, the wedge, and the screw. It may be easily shewn, however, that these are capable of being reduced to greater simplicity. Thus the wheel and axle is only a succession of levers, and the wedge and screw are merely modifications of the inclined plane; hence all the varieties of machinery are reduced to these three simple elements:

1. The lever.
2. The pulley.
3. The inclined plane.



In treating of the use of simple machines, it is usual to consider all bars as perfectly inflexible, cords as perfectly flexible, and surfaces to move on each other without friction, and afterwards to make allowances for these disturbing forces to the weight raised, as 1 to 2. In the diagram, *a e b* is the movable pulley supporting the weight at *e*; *c a e b p* is a cord passing under the movable pulley, and over the fixed pulley at *d*. Now, as the whole weight is supported by the two portions of the cord *c a* and *d b*, each of them sustains one half, and as the passage of the cord over the fixed pulley makes no difference in the proportion, it is clear that the power *p* is equal to half the weight.



When the cords are not parallel, as in the annexed diagram, the angle made by the cords with the perpendicular must be noticed. Thus the force acting in the direction *f c* must be resolved into two others, one pulling in the direction *e c*, and the other in *f e*. Now the force in *e c* does not all act in supporting the weight, which is wholly sustained by that in *f e*: hence the power is to the weight as *c f* is to twice *e f*, and as *c f* is greater than *e f*, the power must be greater than one-half the weight, and, consequently, there is a loss of power by the obliquity of the cords. Sometimes the lower or movable pulley consists of a block containing several small wheels or sheaves, in which case the apparatus is termed a block and fall. The power with such a pulley is easily calculated, by observing the number of cords by which the lower block or fall is supported. If the fall be suspended by six ropes, of course each will sustain one-sixth of the weight, and the power will be to the weight as 1 to 6. In every combination of this kind, therefore, the power is to the weight as 1 to the number of cords supporting the lower block, or as 1 to twice the number of sheaves in the fall.

A modification of this arrangement is seen in the following diagram (*Fig.* 1), of White's pulley: it consists of a number of concentric grooves, formed in a solid mass of brass, &c., the diameters of the grooves being regulated by the quantity of cord that has to pass over each. As these all move on a single axis, considerable reduction of friction is obtained; but the great difficulties

Fig. 1.

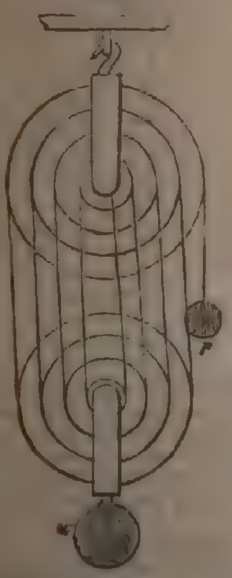
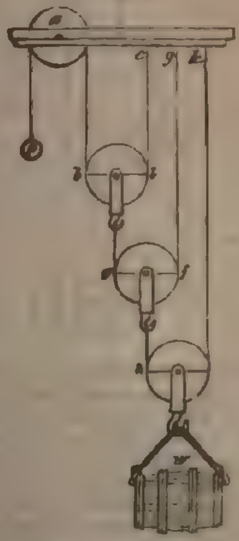


Fig. 2.



attending the construction of this apparatus seem insuperable obstacles to its extensive employment. The power is calculated as in the last example. In the different arrangements hitherto mentioned, a single cord is employed passing round all the pulleys; and if attention be given to the spaces passed over by the part attached to the power and that affixed to the weight, it will be

seen that the same law obtains as in the other mechanic powers,—the space passed over by the power exceeding that passed over by the weight, as much as the weight exceeds the power.

In this arrangement different cords are employed (as in *Fig.* 2 in the preceding page), one to each pulley; there being three movable pulleys, the power is to the weight as 1 to 8: thus suppose the power to be 1 lb., the cords *a b* and *c l* will each support 1 lb.; hence the cords supporting the pulley *e f* will each sustain 2 lbs., and the cords supporting *h i* will each bear 4 lbs. Or, suppose the weight to be sustained by the cord *k i h*, each will support one-half; the cord *g f e* will support one-fourth, and *c l b* will sustain one-eighth. In movable pulleys, then, with separate cords to each pulley, the power is to the weight as the number 2 raised to a power equivalent to the number of pulleys employed. If the number of pulleys had been four, the power gained would have been $2 \times 2 \times 2 \times 2 = 16$.

Another combination, somewhat similar, is seen in the next figure (*Fig.* 1), in which the several cords are attached to the weight; this makes a little difference in the amount of power gained. A power *p* of 1 lb. will sustain a part of the weight equal to 1 lb. This power of 2 lbs. acting at *d*, will support an equal portion of the weight, which, again acting with double force at *g*, will sustain 4 lbs.; hence the quantity supported is $1 + 2 + 4 = 7$ times the power.

Fig. 1.

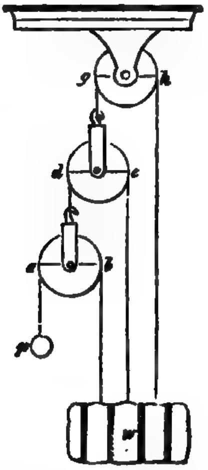
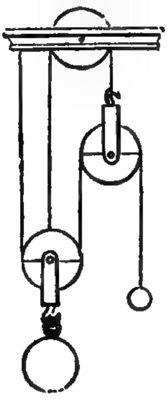


Fig. 2.



Another somewhat different arrangement is shown in *Fig.* 2, in which the one cord passes over a fixed, and the other, over one of the movable pulleys. A power of 1 lb. at *p* would support a weight of 2 lbs. at *w*, and an equal advantage is gained by the attachment of the cord passing over the fixed pulley *a*; the power is therefore one-fourth of the weight. Other combinations sometimes occur, the nature of which will, it is presumed, be understood by reference to those above explained.

MEPHITIC is a term often applied to carbonic acid.

MERCURY is a metal distinguished from all others by its extreme fusibility, which is such that it does not take the solid state until it is cooled to the 39° below 0 in Fahrenheit's thermometer, and is therefore always fluid in the temperate climates of the earth. From this circumstance, and its resemblance to silver in colour and metallic splendour, it has been usually denominated *quicksilver*. The term *mercury*, although almost universally employed by chemical authors, is strongly objected to by Mr. Gray, the author of *The Operative*

Chemist, who complains that "medical authors and chemists of the medical professions, still continue to call this metal (which he denominates *quick) mercury*, that name having been formerly used by the priest-physicians and priest-chemists, to mystify and hoax their patients and the public. It were to be wished that now chemistry and medicine are almost exclusively in the hands of the laity, they would abstain from this ridiculous mummery." The same author also informs us that there are two kinds of quicksilver in the market,—Spanish and Austrian, both of which are very pure; and that "the source of the impure quicksilver in the apothecaries' shops, is the purchase of the *quick* from the silvering tables of bankrupt or deceased looking-glass makers, which is of course impregnated with tin, and sometimes lead and bismuth; this quicksilver is cheaper than the pure, and is thought by them good enough for making blue pill and blue ointment." Mr. Gray does not, however, censure this pernicious practice of the laity, notwithstanding he is so indignant at the presumed alteration of a mere term of doubtful propriety by our learned forefathers. The specific gravity of mercury is at 212° Fahr. 13.375; at 160°, 13.580, and at 40° below zero it increases to 15.632, when it is a malleable solid body. It is volatile, and rises in small portions at the common temperatures of the atmosphere, as is evinced by several experiments, more especially in a vacuum, such as obtains in the upper part of a barometer tube. At the temperature of 650° it boils rapidly, and rises copiously in fumes: it has been attempted to employ the mechanical force which it then exerts as a motive power similar to that of the steam engine; but the loss of the metal, by the extreme subtlety of the vapour passing apparently impervious joints, occasioned, we are informed, its abandonment. Mercury is sometimes found native, but generally combined with sulphur, when it is denominated cinnabar; it is separated from the sulphur by distillation with quicklime or iron filings. Owing to the property which mercury possesses of dissolving completely some of the baser metals, it is extremely liable to adulteration; and the union of the metals is so strong, that they even rise with the quicksilver when distilled. The impurity of mercury is generally indicated by its dull aspect; by its tarnishing and becoming covered with a coat of oxide on long exposure to the air; by its adhesion to the surface of glass; and when shaken with water in a bottle, by the speedy formation of a black powder. Lead and tin are frequent impurities, and the mercury becomes capable of taking up more of these if zinc or bismuth be previously added. In order to discover lead, the mercury may be agitated with a little water, in order to oxidize that metal; pour off the water and digest the mercury with a little acetic acid: this will dissolve the oxide of lead, which will be indicated by a blackish precipitate with sulphuretted water; or to this acetic solution, add a little sulphate of soda, which will precipitate a sulphate of lead, containing, when dry, 72 per cent. of metal. If only a very minute quantity of lead be present in a large quantity of mercury, it may be detected by solution in nitric acid, and the addition of sulphuretted water. A dark brown precipitate will ensue, and will subside, if allowed to stand a few days; one part of lead may thus be separated from 15,263 parts of mercury. Bismuth is detected by pouring a nitric solution, prepared without heat, into distilled water; a white precipitate will appear if this metal be present. Tin is manifested in like manner by a weak solution of nitro-muriate of gold, which throws down a purple sediment; and zinc, by exposing the metal to heat. When the metallic mixtures contain a sufficient quantity of mercury to render them soft at a mean temperature, they are called amalgams. Although it is obvious, from the known inferior specific gravity of iron, lead, and silver, that pieces of these metals will float in mercury, like wood in water, it nevertheless forms a very interesting phenomenon. Mercury is readily soluble in acids, as may easily be ascertained; and from its very extensive use in medicine, there are very numerous preparations of it, by which it may be exhibited in powders, pills, or drops. The most usual is calomel, which is a preparation of mercury and muriatic acid, or chlorine, and is hence called, according to the modern nomenclature, proto-chloride of mercury. The deuto-chloride, or corrosive sublimate, is another combination of mercury and chlorine, and forms one of the most powerful and

useful, but dangerous medicines, man has ever discovered. Mercury will unite with sulphur. Melt some sulphur in a crucible on the fire, then a little mercury, and stir the whole well together, and a sulphuret of mercury, cinnabar, will be formed. That beautiful scarlet pigment called vermilion (see the separate article) is also prepared from mercury and sulphur, and is called by chemists the red sulphuretted oxide of mercury. The property of mercury, dissolving a certain portion of gold and silver, enabled alchymists to impose upon mankind, and make it appear as if they had succeeded, in a small degree, in discovering the secret of turning metals into gold and silver. In their operations they employed mercury in which small portions of these metals had been dissolved; and as the mercury was evaporated by great heat, and left the gold and silver behind, the bye-standers were made to believe that these metals had actually been produced in operation by the skill of the experimentalist. Looking-glasses and mirrors are covered on the back with an amalgam of tin, and the glasses are afterwards loaded with weights, to press out gradually the superfluous mercury, which thus exudes from the amalgam. Amongst the numerous uses of this valuable metal, the application of it in the construction of barometers and thermometers is not the least important. See those inventions.

METALLURGY, in a general sense, comprehends the art of working metals from the state of ore to the utensil; and in this sense, assaying, smelting, refining, smithery, &c., are branches of metallurgy. In a more limited sense, however, it includes only the separation of metals from their ores or other combinations. Few metals are found in a pure state; gold, silver, and copper are sometimes exceptions; the other metals are generally found in the state of ores, in which they are mixed and blended with other substances, so as not to have the ductility, lustre, or other qualities of metals. Sometimes the ore is only a pure oxide, and requires but the abstraction of the oxygen by fusion with inflammable substances. The ores of metals are always separated from the rocks on each side by a quantity of spar, quartz, or sometimes clay or earth, called the matrix or rider. The first operation in metallurgy is to separate the ore from the matrix; but when the ore is found in large masses, most of it can be obtained by the miner's implements free from the matrix, and those portions that adhere are knocked off by hammers. In other cases, when the ore is intimately mixed with the matrix, it becomes necessary to resort to different processes, such as roasting, pounding, and washing; the last operation effecting the separation by the difference of specific gravity of the mixed matters; the earthy parts being floated away, leaving the metallic portions behind. See the following article.

METALS. A numerous class of undecompounded bodies, which are distinguishable by their lustre, ductility, malleability, tenacity, opacity, &c. They are fusible by heat, and in fusion retain their lustre and opacity; and they are all, except selenium, excellent conductors, both of electricity and caloric. When they are exposed to the action of oxygen, chlorine, or iodine, at an elevated temperature, they generally take fire, and combining with one or other of these three elementary dissolvents, in definite proportions, are converted into earthy or saline-looking bodies, devoid of metallic lustre and ductility, called oxides, chlorides, or iodides. They are capable of combining in their melted state with each other, in almost every proportion, constituting the important order of metallic alloys. From their brilliancy and opacity conjointly, they reflect the greater part of the light which falls on their surface, and hence form excellent mirrors. "The relations of the metals to the various objects of chemistry," Dr. Ure observes, "are so complex and diversified as to render their classification a task of peculiar difficulty. I have not seen any arrangement to which important objections might not be offered; nor do I hope to present one which shall be exempt from criticism. The main purposes of a methodical distribution are to facilitate the acquirement, retention, and application of knowledge. With regard to metals in general, I conceive these purposes may be to a considerable extent attained, by beginning with those which are most eminently endowed with the characters of the genus, which most distinctly possess the properties that constitute their value in common life, and which caused the early inhabitants of the

GENERAL TABLE OF THE METALS, BY DR. URE.

Names.	Specific Gravity.	Precipitants.	Colour of Precipitates by Ferroprussiate of Potash	Colour of Precipitates by Infusion of Galls.	Colour of Precipitates by Hydro-sulphurets	Colour of Precipitates by Sulphuretted Hydrogen
1. Platinum	21.47	Mur. ammonia	0	0		Black and metal
2. Gold	19.30	Sulph. iron; Nitr. mercury	Yellowish white	Green; red	Yellow	Yellow
3. Silver	10.45	Common salt	White	Yellow brown	Black	Black
4. Palladium	11. 8	Prussiate mercury	Deep orange		Blackish brown	Black brown
5. Mercury	13. 6	Common salt	White passing to yellow	Orange yellow	Brownish black	Black
6. Copper	8. 9	Iron	Red brown.	Brown	Black	Ditto
7. Iron	7. 7	Succin. soda, with peroxide	Blue, or white passing to blue	Purple 0; Green black	Ditto	0
8. Tin	7.29	Corro. sublimate	White	0	Brown black; Fawn yellow	Brown
9. Lead	11.35	Sulph. soda	Ditto	White	Black	Black
10. Nickel	8. 4	Sulph. potash	Ditto	Grey white	Ditto	0
11. Cadmium	8. 6	Zinc	Ditto	0	Orange yellow	Orange yellow
12. Zinc	6. 9	Alk. carbonates	Ditto	0	White	Yellowish white
13. Bismuth	9.88	Water	Ditto	Yellow	Black brown	Black brown
14. Antimony	6.70	Water; Zinc	With dilute solutions, white	White from water	Orange	Orange
15. Manganese	8.	Tart. potash	White	0	White	Milk brown
16. Cobalt	8. 6	Alk. carbonates	Brown yellow	Yellow white	Black	0
17. Tellurium	6.15	Water; Antimony	0	Yellow	Blackish	
18. Arsenic	8.35; 5.76?	Nitr. lead	White		Yellow	Yellow
19. Chromium	5.90	Ditto	Green	Brown	Green	
20. Molybdenum	8. 6	Ditto	Brown	Deep brown		Brown
21. Tungsten	17. 4	Mur. lime?	[illegible]			
22. Columbium	5. 61	Zinc, or inf. galls	Olive	Orange	Chocolate	
23. Selenium	4. 31	Iron; Sulph. ammonia				
24. Osmium	?	Mercury		Purple passing to deep blue		
25. Rhodium	10 65	Zinc?	0		0	
26. Iridium	18.68	Ditto?	0	0		
27. Uranium	9. 0	Ferro-prus. potash	Brown red	Chocolate	Brown yellow	0
28. Titanium	?	Infusion galls	Grass green	Red brown	Grass green	0
29. Cerium	?	Oxal. ammon.	Milk white	0	White	0
30. Potassium	0.865	Mur. plat.; Tart. acid	0	0	0	0

to give to the first metallurgists a place in mythology. Happy had their idolatry been always confined to such real benefactors! By arranging metals according to the degree in which they possess the obvious qualities of unalterability, by common agents, tenacity, and lustre, we also conciliate their most important chemical relations, namely, those to oxygen, chlorine, and iodine; since their metallic pre-eminence is, popularly speaking, inversely as their affinities for these dissolvents. In a strictly scientific view, their habitudes with oxygen should perhaps be less regarded in their classification than with chlorine, for this element has the most energetic attraction for the metals. But, on the other hand, oxygen, which forms one-fifth of the atmospheric volume, and eight-ninths of the aqueous mass, operates to a much greater extent among metallic bodies, and incessantly modifies their form, both in nature and art. Now the order we propose to follow will indicate very nearly their relations to oxygen. As we progressively descend, the influence of that beautiful element progressively increases. Among the bodies near the head, its powers are subjugated by the metallic constitution; but among those near the bottom, it exercises an almost despotic sway, which Volta's magical pile, directed by the genius of Davy, can only suspend for a season. The emancipated metal soon relapses under the dominion of oxygen." This table is given at page 143.

The first 12 metals are malleable, and so are the 30th, 31st, and 32d, in their congealed state. The first 16 yield oxides, which are neutral salifiable bases. The metals 17, 18, 19, 20, 21, 22, and 23, are acidifiable by combination with oxygen. Of the oxides of the rest, up to the 30th, but little is known. The remaining metals, sodium, lithium, calcium, barium, strontium, magnesium, yttrium, glucinum, aluminum, thorinum, zirconium, and silicium, form, with oxygen, the alkaline and earthy bases.

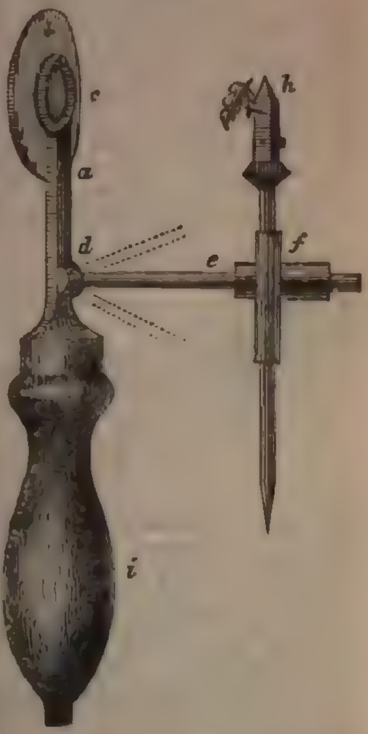
MICA. A mineral, which Professor Jameson divides into ten species; but the term is generally understood to imply talc, or Muscovy glass, which is one of the species. Most of the mica or talc of commerce is brought from Siberia, where it is used as a substitute for window-glass. In this country it is employed for similar purposes where violent agitation or great heat would be destructive of common glass. It is also used for enclosing objects for microscopes, for which it is admirably adapted; consisting, as it does, of an unlimited series of transparent laminæ adhering to each other, which easily separate into extremely thin flexible plates, by the application of the fine edge of a pen-knife.

MICROMETER. An instrument of which there are various constructions, usually applied to telescopes and microscopes, for the purpose of measuring minute bodies, or small angles formed by bodies at a remote distance, by which their real magnitude is obtained. To the modern introduction of this instrument for the use of the astronomer, and to the improvement of the telescope, may be attributed our present accurate and extensive acquaintance with the universe of matter; while, from the perfection to which the microscope has been brought, an equal acquaintance with the organization of minute bodies may be expected. By the application of the micrometer to the latter instrument, the power of the naturalist is materially extended; while the micrometer is of the utmost value for trigonometrical surveys, and in military and naval operations.

MICROSCOPE; from two Greek words, signifying *small*, and *to view*. An optical instrument for viewing small objects, rendering those visible which cannot be distinguished by the naked eye, and magnifying those that can. The forms of microscopes are very numerous, but they may all be included in three distinct classes, namely, *single*, *compound-refracting*, and *compound-reflecting* microscopes. A simple, or single microscope, is that which consists of a single lens or single spherule. Most persons may have observed, that when the distance of an object is decreased, we are enabled to define its parts more readily, and that it appears larger; thus, if we look at two men, the one at 200 feet, and the other at only 100 feet from us, the former will appear only half the height of the latter; or the angle which the latter forms with the eye of the observer will be twice that of the former. Hence the nearer we can bring an object to the eye, the larger it will appear. If we have to examine a very minute object, and in order to render its parts distinguishable, if we bring it

very near to the eye, (suppose one or two inches,) it will become very indistinct and confused. This effect is produced by the great divergency of the rays of light from the object, and the power of the crystalline lens of the eye not being sufficient to collect the rays, whereby an image of the object may be formed on the retina, at the proper distance at the back of the eye. But if we employ a single microscope, which consists of a convex lens, usually made of glass, (though it would have the power of magnifying or increasing the angle, if made of any other transparent substance, but in a different degree,) mounted or fixed in brass, and place it between the object and the eye, the former being in the focus of the glass, the diverging rays from the object will be refracted and rendered parallel by the lens, and we shall thus obtain a near and distinct view of the object. The quantity of light necessary to be employed in using a microscope is dependant on the nature of the object under examination, and on the magnifying power of the lenses necessary for its developement.

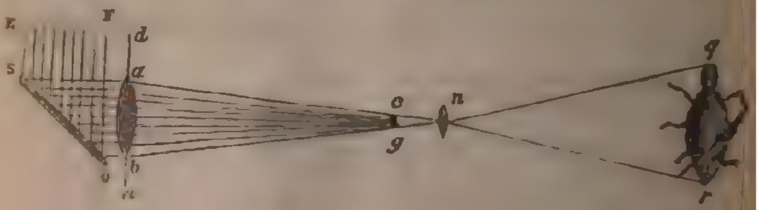
The annexed figure is a single microscope; *a* is the brass stem; *c* the cell containing the lens *c*; at *d* there is attached an arm *e*; this arm, being jointed at *d*, is capable of lying flat, or being altered to any convenient position for viewing the object, as shown by the dotted lines; on the round arm *e* is a sliding tube *f*, fixed to another tube at right angles, which carries the forceps *h*, movable in every direction with respect to the lens *c*; the handle *i* is screwed to the stem *a* when in use. This is the most convenient form of a single microscope.



A compound refracting Microscope is an instrument consisting of two or more convex lenses, by one of which an enlarged image of the object is formed, and then by means of the other, employed as an eye-glass, a magnified representation of the enlarged image is obtained. The distance at which the two lenses of a compound microscope are placed from each other must always exceed the sum of their focal lengths, in order that the image may be formed by the object-glass in the exterior focus of the eye-glass. The great distinction between single and compound microscopes is, that in the latter we only view a magnified *image* of the object, while in the former we see the *object itself*. From this it must be evident, that unless the image formed by the object-glass be a perfect representation of the object in every particular, its imperfections, however small, will be increased by the eye-glass, in the same ratio as it magnifies the image. On account of this disadvantage, the compound microscope had been entirely laid aside by the most distinguished naturalists and philosophers till very lately. For general purposes it is prefered, on account of the extent of field obtained by it, which is far greater than that obtained by ordinary single glass lenses of equal power. For these purposes, there is usually introduced a third, or field-glass, by which the extent of view is still further increased by the rays being bent by this lens, so that a greater portion of them may be refracted by the eye-

glass. The annexed figure is a section of a compound microscope; r is the object intended to be magnified, which is placed in the focus of the object-glass o; by this lens, an enlarged and inverted image is formed at $i\,i$, in the focus of the eye-glass c; f is a field-glass, by which the extent of the view is increased from the diverging dotted lines to $i\,i$, by the rays being bent by this lens, so that a greater portion of them is refracted by the eye-glass c.

The Solar Microscope consists of a common microscope, connected to a reflector and condenser, the former being used to throw the sun's light on the latter, by which it is condensed to illuminate the object placed in its focus. This microscope is sometimes called the Camera Obscura Microscope, but it still more nearly resembles the magic lantern in its effect. The exhibition it affords is made in a darkened room, and it can only be used when the sun shines. This instrument usually consists of one plane mirror and two lenses. The mirror $s\,o$ must be without the window shutter $d\,u$; the lens $a\,b$ fixed in the shutter; and the lens n within the room. The lens $a\,b$ is inclosed in a brass tube, and the other in a smaller tube, which slides in the former, for the purpose of adjusting it to the proper distance from the object. The mirror can be so turned by adjusting screws, that however obliquely the incident rays F F fall upon it, they can be reflected into the dark room through the illuminating lens $a\,b$ in the shutter. This lens collects those rays into a focus near the object, and, passing on through the object $c\,g$, they are met by the magnifier n; here the



rays cross, and proceed divergently to a vertical white screen prepared to receive them; on which screen, the image or shadow $q\,r$ of the object will appear. The magnifying power of this instrument depends on the distance of the white screen, and in general bears a certain proportion to the distance of the object $c\,g$ from the magnifier n; that is, if the screen be at ten times that distance from the lens n, the image will be ten times as long, and ten times as broad as the object. About ten or twelve feet is the best distance; for, if further off, the image, though larger, will be obscure and ill defined. The apparent magnitude of objects is measured by the angle under which they are seen by the eye, and those angles are reciprocally as the distances from the eye. If eight inches be assumed as the nearest limit of a distinct vision to the naked eye, and by interposing a lens, we can see with equal distinctness at a nearer distance, the object will appear to be as much larger through the lens than to the naked eye, as its distance from the eye is less than the distance of unassisted vision. If the focal distance of a convex lens be one quarter of an inch, or the thirty-second part of the common limit of vision, or eight inches, the lineal dimensions of an object examined with it will be magnified thirty-two times, and its surface 1024 times, or the square of 32.

The simplest microscope which can be employed to any useful purpose, is that which is made with a drop of water, suspended in a very small hole in a thin slip of brass, or any similar material. A spherule of water, however, of

the same size as one of glass, will not magnify so much as the latter, because, as its density is not so great, it has a longer focus. A drop of water placed on the end of a slender piece of brass wire, and held to the eye by candle-light, will, without any other apparatus, magnify, in a very surprising manner, the animalculæ contained in it. These water microscopes have given rise to the use of various other fluids, with several varieties of construction. Dr. Brewster, instead of water, has made use of very pure and viscid turpentine, taken up by the point of a piece of wood, and dropped successively upon a thin and well-polished glass. The same gentleman has also used sulphuric acid and castor-oil, both of which possess a refractive power considerably greater than water. Fluid lenses have been employed as the object-glasses of compound microscopes. Minute glass spherules make excellent microscopes, but the foci of the smallest sort are so short, that it requires considerable attention and patience to employ them well.

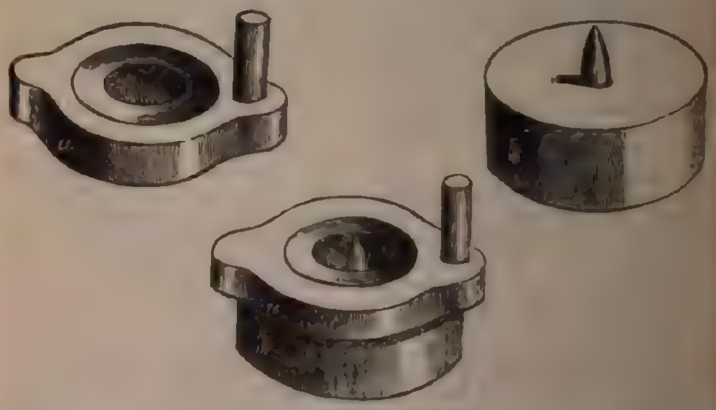
MILK. A fluid secreted by the females of the class *mammalia*. Although the proportions of its constituents vary in different animals, its general properties are the same in all. When this fluid is allowed to stand for some time, it undergoes spontaneous changes, and is resolved into its component parts: a thick yellowish substance collects on the surface, which is *cream*, while the milk beneath becomes thinner than before, and is of a pale bluish colour. When cream is kept for some days without being disturbed, it gradually becomes thicker, till at last it acquires the consistence of cheese; so that one method of making cream cheese is merely by putting cream into a linen bag, and leaving it there till it becomes solid. When cream is shaken, it is resolved into its component parts. The process by which this is accomplished is called churning, whence two products result,—*butter* and *butter-milk*. In the making of butter, cream is allowed to stand for some time, during which an acid is generated. It is then put into a churn and agitated, by which the butter is gradually separated; what is left (the butter-milk) has a sour taste, but not so much as that of the cream before churning. Butter is also sometimes made from cream which has not become sour, but the process is much more tedious, owing to the want of acid to favour the separation. Butter is merely an animal oil, solid at a natural heat, but held in solution, in milk, by some of the other substances; thus obtained, however, the butter is not pure, and requires much washing in water to free it from its impurities, and, by the subsequent addition of salt, it may be kept good a long time. Milk from which butter has been taken undergoes spontaneous changes; it becomes much sourer, and assumes a gelatinous form. When heated, the fermentation of this coagulum is hastened, and, by the addition of certain substances, it very soon takes place; thus acid and spirits of wine curdle it, which is owing to the albumen it contains being acted upon by them in the same way as blood or white of eggs. By far the most powerful coagulator, however, is the substance called *rennet*. When the milk is previously heated, and rennet added, it instantly coagulates. If the coagulum be cut, a thinnish fluid oozes from it; and if it is put into a bag and squeezed, the whole of this is forced out, and a whitish tough matter remains; the former is *whey*, and the latter *curd*. On this depends the process of making cheese, which varies in richness according to the mode followed in preparing it. When milk is heated gradually, and merely to the temperature at which it curdles, and the curd freed gently from the whey, it retains almost the whole of the cream, which adds to its richness and flavour; but when it is curdled quickly, and the whey is speedily removed by cutting the curd, a great deal, or nearly the whole of the cream is carried off, and the cheese is poor, and has not the rich flavour of cheese made in the other way. The latter is the method usually followed in Scotland, where both cheese and butter are obtained from milk,—the whey procured in the process yielding a considerable quantity of the latter, and hence the comparative poorness of Scotch cheese. In making cheese, having obtained the curd, and freed it from its whey, the remaining part of the process is merely to subject it to pressure, by which the whole of the whey is forced out; the colouring ingredient is generally annotta, to give it the desired tint.

Milk, according to the analysis of Berzelius, consists of—

	Parts.
Water	928.75
Curd, with a little cream	28.00
Sugar of milk	35.00
Muriate of potash	1.70
Phosphate of potash	0.25
Lactic acid, acetate of potash with a trace of lactate of iron	6.00
Earthy phosphates	.30
	1000 00

The same chemist found cream of spec. grav. 1.0244, by analysis to consist of butter 4.5, cheese 3.5, whey 92.

MILLS are machines for triturating all kinds of substances capable of being reduced or pulverized by their action. Those employed for converting grain into flour, by rubbing it between two hard surfaces, are generally of stone. The earliest species of mills were of a very rude and simple construction, consisting of two flat stones, one placed on the other, and the uppermost turned by hand, resembling the figures shown in the following engraving, which represents a hand-mill in



nearly universal use at the present day amongst the eastern countries. The two stones are put together, as in the figure, and the upper one is then turned by hand round the central pivot. Mills of this description were in common use amongst the Egyptians, Hebrews, Romans, and other nations of antiquity, and continued in use in the Highlands of Scotland until a very recent date; the *principle* is indeed the same as that of our most modern and improved mills, but it is only adapted for grinding small quantities of grain at a time.

Under the head HAND-MILLS we have described two mills, which were designed to illustrate a mode of applying manual power to such machines, that has been deemed by various eminent writers on mechanics as the most efficient; namely, that of *rowing*. But however energetic that action may be, it does not appear to have stood the test of experience; probably on account of it not being so convenient at all times as that of the winch, which is, besides, much more compact, and requires for its use no previous initiation. The ordinary kind of small hand-mills resemble closely those metallic coffee-grinders which almost every person has in his possession, or may see in constant requisition in the shops of grocers. A few words will describe the whole of this class.—They

consist of one central solid frustrum of a cone, the outer circular surface of which is cut spirally into furrows, so as to present at the upper edges of the latter a continuous series of angular teeth. On the outside of the latter is fixed concentrically a hollow frustrum of another cone, similarly cut into grooves, and so proportioned to the former, that at one extremity the opposed grooves almost touch each other, and at the other they are so far apart as to admit the articles to be ground whole. These concentric conical grinders are fitted up in a variety of ways. In the little box-mills the axes of the cones are usually vertical; but in the fixed, or post-mills, the cones are horizontal. in both, they are surmounted with hoppers to convey the materials to the grinding surfaces, and the products of the trituration are received into either fixed or loose receptacles beneath. By the revolution of the inner cone, the substances are first broken in the widest part of the annular crevice, and being thus reduced in size, they gradually sink, or are forced into narrower and narrower spaces, until they emerge from the grinders in a state more or less comminuted, according to the adjusted space between the grinders, which is usually performed by a screw passing through a traverse bar, with its end bearing against one end of the revolving grinder, so as to limit the extent of its separation or distance from the fixed grinder. Mills constructed upon the same principle are almost universally applied to a great variety of useful purposes; and the manufacture of them is one of considerable extent in Birmingham and other places. But however valuable their application generally, they are but ill adapted to the grinding of corn advantageously, because the perfection of that art consists in an exact separation of the husk, or bran and pollard, from the pure flour; and the operation cannot be successfully performed if the corn be much cut to pieces, which mills of the kind just described almost invariably do when they are in order, or sharp; and when they are dull from wear, the mills soon clog, if set close,—or if set open, a very wasteful quantity of flour is left upon the bran or other offal. These defects arise, in our opinion, from an erroneous mode of construction. Corn and grain generally are extremely solid compact, bodies, and when reduced to powder or meal they occupy a much larger space than previously; consequently, as the grinding progresses, the spaces for the reception of the comminuted matter should be proportionally *enlarged;* but it will be observed, that the annular crevices between the concentric cones, where the grinding takes place, are rapidly *contracted* into a very acute angle. Here the clogging necessarily occurs; and unless the grinders be set considerably wider apart, so as to let the meal pass out in an extremely coarse state, the meal, by the continued attrition (or *kneading* as it were) becomes converted into a pasty, blackened mass. From a series of experiments made with cones of various inclinations by the writer, evidence, conclusive to his mind, was afforded of this fact, that, in proportion as the concentric cones were reduced in their height, did the flour improve; and, finally, when he brought the surfaces down to a perfect *flat*, the products of the grinding were, in the language of the miller, *more lively*, and of a *better colour*, than in any previous experiments. From the singularly beautiful and ingenious device of concentric conical grinders, and their compactness, it is almost to be lamented that they do not succeed better with wheat. There is, however, another defect attached to these mills, which we ought not to forbear noticing; this consists in the spiral grooves forming a series of continuous cutting edges, which clip the grain to pieces, and cause much of the husk to be ground fine, and be inextricably mixed with the flour; whereas, the action ought to be that of simple crushing, in the first part of the operation, which flattens the husk, and permits the flour to be afterwards rubbed and scraped from its surface, without incurring much subsequent minute subdivision to the detriment of the flour.

A very elegant and compact corn-mill was constructed in France, and was adopted by Buonaparte for the uses of his vast army when he invaded Russia in 1812. Hence it was called the French military mill, and it was introduced subsequently into this country on account of its portability and convenience. It consisted of two circular cast-iron plates, about 12 inches in diameter, placed in a vertical position, one of which was fixed, and the other rotative, upon a

horizontal axis, turned by a winch. The plates were indented all over with radiating grooves; the corn was conducted to the centre, or eye, by means of a lateral hopper, and the meal, as it was ground, was projected from around the periphery by the centrifugal force of the revolving plate.

In 1824, Messrs. Taylor and Jones took out a patent for some improved appendages or adjustments to this mill; but there is reason to believe that the undertaking failed from an inherent defect in the construction of the original. The vertical position of the plates is unquestionably disadvantageous, as the effect of gravity is always counteracting the centrifugal action, and necessarily causes a larger portion of the meal to descend from underneath than from the sides or the top; and this tendency, we suspect, must have rendered it expedient to work very close, to prevent the meal dropping out in a coarse state: and from the greater resistance of the meal on the lower side than on the upper, the plates were liable to spring or separate more underneath; or if unyielding, by reason of their solidity and perfect centering, a deterioration of the meal seems to be the necessary result.

Many attempts have been made to grind wheat by stones running vertically, both here and in America, but a little experience in their working has generally led to their abandonment. A variety of machines have, likewise, been constructed for domestic use, wherein the dressing-machine, or bolter, has been annexed to the mill, so that the two processes shall be conducted consecutively within the same framing. Such machines, therefore, represent the apparatus of the great public mills in miniature; but they confer no advantages, because they are equally complex, and are put together in an inferior manner. Viewing the subject in this light, the writer, a few months ago, directed his thoughts to the simplification of the millering apparatus; and he so far succeeded, as to perfectly grind and dress upon the *same* continuous surface, which appears to be the limit of invention, at least as far as the principle is concerned. The following account of this machine is extracted from the *Mechanics' Magazine*, No. 665.

"*Hebert's Patent Flour-making Machine.*—From a personal inspection of the machine delineated in perspective on the following page, and from a careful perusal of the inventor's specification, it appears to us to be his design to construct flour-mills of the utmost simplicity and durability; in which, not only the *grinding* of the corn, but the *dressing* (sifting) of the meal into flour, pollard, bran, &c., are simultaneously performed. It is not, however, to be understood that these combined operations are effected by the mere *annexation* of a dressing-machine to a mill, and driving them both together; for in such an arrangement there would be neither novelty nor economy. But the combined operations of grinding and dressing are in this new patent mechanism so simplified, and so intimate, that they are continuously going on, *upon one continuous surface.* The essential members of the machine are thereby reduced to only *two!* one stationary, the other rotative. This remarkable simplicity conduces to many advantages, which our mechanical readers will at once appreciate, without our entering upon the details. The inventor has shown in his specification, and has actually put into beneficial practice, several modifications of the principle so as to adapt the scale of their operations to any required magnitude. We have selected for the present article what the patentee denominates his patent *domestic* flour-maker, which is adapted to the manual force of one man; but the power requisite to work this may be diminished or increased at the pleasure of the operator, by a corresponding reduction or augmentation of the *feed*, or quantity of corn permitted to pass under the operation of the grinders in a given time. In a subsequent number we purpose inserting a description of one of the same kind of machines, which is in use at the workhouse of All Saints, near Hertford, where it is worked by any number of men, from two to ten, (by a suitable alteration of the feed,) and is capable of properly grinding and dressing as much corn in a given time as other mills will grind only; the estimated power required to work it efficiently being that of one horse, whether worked by that animal, or by wind, water, or steam.

"We shall now proceed to describe the hand-mill, with reference to the

engraving before adverted to. *a* is an axis, mounted in plummer-blocks *b b*, and turned by a winch *c*, assisted, if required, by a handle *d*, fixed to one of the arms of the fly-wheel *e e*. The axis *a* also carries a bevelled wheel *f*, which drives a pinion *g*, fixed upon a vertical spindle *h*, that revolves in the centre of a metallic hopper *i*, and carries at its lower extremity the upper grinder; and

to the periphery of the latter is attached a series of brushes, that revolve together with it inside the circular case *j*, cast in one piece with the hopper *i*. The lower grinder is fixed in the centre of the flat top *k* of the pedestal; and around the lower grinder, in the same plane as its superior surface, is an annulus of fine wire-gauze; over the area of which the brushes sweep in their revolution, continually scattering every particle of the meal, as the same is constantly projected in minute quantities all around the peripheries of the grinders, on to the wire-work; causing the flour to fall through the meshes into the drawer *m m*, below;

while the bran and pollard, which cannot pass the wire-gauze, are continually being freed from their adhering flour by the action of the brushes, until they are driven through an aperture at the outer circumference of the wire-gauze, on to an inclined screen of coarse wire-work, where the offal separates itself, in the mere act of falling, into pollard and bran, both of which deposit themselves into separate compartments made in the drawer *n*. At *l* is a screw for regulating the admission of the corn; and at *o* is a lever over an engraved plate, which directs the operator which way to move it, according as he may desire to regulate the grinding, whether coarser or finer than it was previously set. These adjustments are obvious to the sight, and unerring in their action.

"Amongst the advantages which this machine presents to the economist may be stated its convenience, portability, and perfect cleanliness, and there being no dust or waste of any kind. It is particularly adapted for the use of domestic families, who are desirous, not merely to make their own bread, but to be sure that the flour which they use is a genuine product of good wheat. As respects its utility to emigrants and distant settlers, we have reason to believe that its merits have already been very satisfactorily tested; the durability of the grinding surfaces being such as to render a renewal of them apparently unnecessary for a series of years. A mill of this kind may be seen at No. 20, Paternoster-row."

Since the foregoing account appeared in the Mechanic's Magazine, several valuable improvements have been made in the machine. The wire gauze through which the metal is sifted, is now rendered capable of being easily withdrawn, so as to convert the machine into a simple mill, the whole or gross produce being at once deposited in the large drawer: its utility is thus much extended, as there are many substances that do not require sifting.

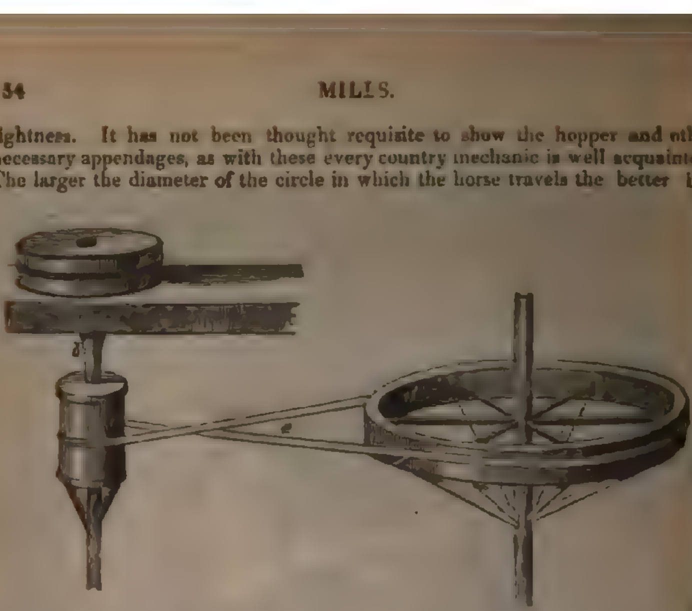
Owing to a mistake made by the draftsman, the pedestal of the mill in the foregoing cut is represented as disproportionally small. With reference to the larger class of machines constructed on the same principle, and alluded to in the foregoing extract, as being in operation at Hertford, we may be permitted to observe, that one of the prominent disadvantages of the working of mills and dressing-machines of the ordinary construction in a workhouse, is the necessity of employing a *paid* servant to superintend and direct their operations: to which may be added the frequent stoppages in the work, for taking up the stones to recut, or dress their surfaces anew, a process which requires great millering skill and practical experience to execute in an efficient manner; and however ably it may be performed, it unavoidably entails a great waste of time, much labour, and wear and tear of tools and machinery. But the extraordinary simplicity of this patent machine, (which is now being introduced into several of the workhouses conducted under the new system of poor laws,) renders the management of it so easy and obvious, that the master of the workhouse can, without any difficulty or inconvenience, superintend its operation, or depute any unskilled labourer, in whom he can confide, to occasionally look to its performance; as the machine requires no active duty, but continues to perform, uniformly for months together, all its operations of grinding, dressing, and separating its various products of flour, pollard, bran, &c. without any interference, but that of keeping it clean and properly oiled.

The mechanical arrangements of this new machine equally adapt it to the production of every quality of flour and meal that may be required; to grind and dress finer or coarser, at the pleasure of the operator; to grind, break, or crush only, without dressing; to dress only, without grinding; and may be equally well worked by any number of men or boys, from only one up to twenty, the quality of the products being the same, and the difference only in the quantity. A machine of this kind has now been in active operation for several months, at All Saints' Workhouse, of the Hertford Union, the guardians of which, as well as the master, Mr. Booth, have testified to the facts just mentioned. The framing of this machine is made partly of oak, but all those since constructed are entirely of metal, and combine other improvements, which add to their practical convenience; one of which may be seen in operation at

Dr. Allen's excellent establishment for the cure of mental diseases, at High Beech, near Woodford, Essex.

The following description of an economical horse-mill, for grinding corn, is extracted from a communication in the *Franklin Journal* for July, 1826, addressed to the farmers and planters of the United States:—*a a* are the mill-stones; *b* the spindle, which supports the upper stone; *c* a drum upon the spindle made long to prevent the band slipping off; *d* a large gin with its shaft, and arms (the lever to which the horse is yoked is not shown); *e* the bolt of tanned leather, five or six inches broad, with a buckle to give it the necessary

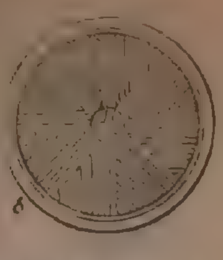
tightness. It has not been thought requisite to show the hopper and other necessary appendages, as with these every country mechanic is well acquainted. The larger the diameter of the circle in which the horse travels the better, but



it should on no account be less than 18 feet; the proportion of the large and small drums must be regulated by the size of the stones and the diameter of the horse-track: and it would in most cases be found best to place the hopper and stones under cover, as in the corner of a barn, and the large gin outside, by which means a large horse-track might be formed, and the mill might likewise be driven in wet weather. In the mill previously noticed at Dr. Allen's the usual necessity of a horse-wheel is entirely obviated.

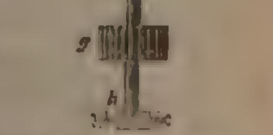
The largest description of corn-mills in the present day are driven either by water, wind, or steam. Watermills were in use amongst the Romans, who established several of them in this island; the mill-course of one of these was discovered some years back near Manchester. Windmills, we believe, were likewise known to them; but the application of steam to this purpose is of very recent date, the first steam-mills established in this or any other country being those erected by Bolton and Watt, near Blackfriars' Bridge, and named the *Albion Mills*. Whatever be the nature of the driving power, the grinding apparatus is nearly alike in all their mills; and as both windmills and watermills are employed for various purposes besides that of grinding corn, we propose under the head WATERMILL and WINDMILL, to notice the methods of applying the power derived from these sources, and shall, in this place, give a description of a mill of modern construction, as driven by steam: we should, however, observe, that under the head BARKER'S MILL, the reader will find a water corn-mill of a simple description.

We shall preface our description of the mill by a short account of the form and the manner of facing the millstones. In order to cut or grind the corn, both the upper and under millstones have channels or furrows cut in them, proceeding obliquely from the centre to the circumference, as shown in the figure on p. 155. The furrows are cut perpendicularly on one side, and obliquely on the other, into the stone, which gives to each furrow an inclined plane, up which the corn is forced by the revolution of the upper stone, which crushes it and bruises it so as to make it grind easier when it falls upon the spaces between the furrows. These are cut the same way in both stones, where they lie on their backs (as above represented), which makes them run crossways to each other, when the upper stone *a* is inverted, and its furrowed side applied to the furrowed side of *b*. When the furrows become blunt and shallow by wearing, the running-stone must be taken up, and both stones new dressed with a chisel; and every time that the stone is taken up, a small portion of tallow should be applied to the bush of the spindle.



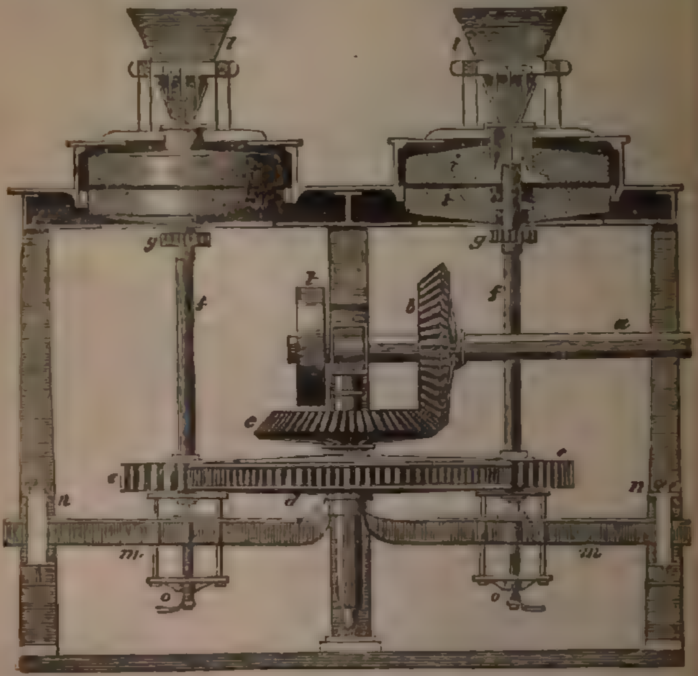
The grinding surface of the under millstone is a little convex from the edge to the centre, as exhibited in the annexed section at *b*, and that of the upper stone a little more concave, so that they are furthest from one another in the middle, and come gradually nearer towards the edges. By this means, the corn at its first entrance between the stones is only bruised; but as it goes further on towards the circumference, or edge, it is cut smaller and smaller, but at last finely ground just before it comes out from between them.

But although, in the diagram above given, the concavity in the upper stone corresponds with that described by several authors, we believe that the upper stone is not usually cut away to a greater extent beyond the mill-eye than that shown in the figure in the margin p. 151, where the grain is shown entering the mill-eye, and passing through the apertures of the rind *c*, it enters the cavity underneath; here it gradually gets broken, bruised or coarsely ground, and from thence the finest portion enters between the *parallel* surface of the millstones, and by degrees passes from between them at their peripheries, being constantly urged outwards by the pressure of the grain in the middle, as well as by the centrifugal force. The rind *c* is an iron cross let into the upper mill-stone, and is fixed to the spindle *e*; and the cavity *f* is filled completely by a bush (generally of wood), in which the spindle revolves. The trundle *g*, (driven by a cog-wheel, which is actuated by the first mover,) gives motion to the spindle and the upper stone. The surface of the upper stone is brought to a perfectly parallel position with respect to the other, by means of four equidistant regulating screws, acting upon a brass box *h*, in which the lower extremity of the spindle works; so that the slightest movement of the box, effected by the screws, makes a correspondent alteration in the position of the upper stone, enabling it to be adjusted to the lower one with the nicest precision and the greatest facility.



We shall now proceed to describe the engraving on p. 156, which represents a very compact arrangement of a mill, having four pair of stones driven by a steam-engine. The stones are placed at equal distances from the centre of a circular platform, resting upon cast-iron columns, and the driving is arranged beneath the platform, and supported by a framing of iron fixed to the columns. *a* is the horizontal shaft driven by the steam-engine, on which is fixed the bevil-wheel *b*, working into another bevil-wheel *c*, of equal diameter, fixed upon the same vertical shaft which carries the large spur-wheel *d*; this spur-wheel works into four pinions *e e*, fixed upon the spindles *f f* of the upper millstones, only two of which can be seen; *g g* are indented pinions, for the purpose of agitating

the sieves placed over the hoppers, for preventing stones and other extraneous substances entering the hopper; *i i* are the upper millstones; *k k* the lower millstones; *l l* the hoppers, from which the corn descends into a swinging kind of hopper, called the shoe, which is continually shaken by a short bar of iron screwed into the upper end of the spindle, and having four prongs, which, striking the shoe from side to side, distributes the corn equally over the eye of the mill stone.

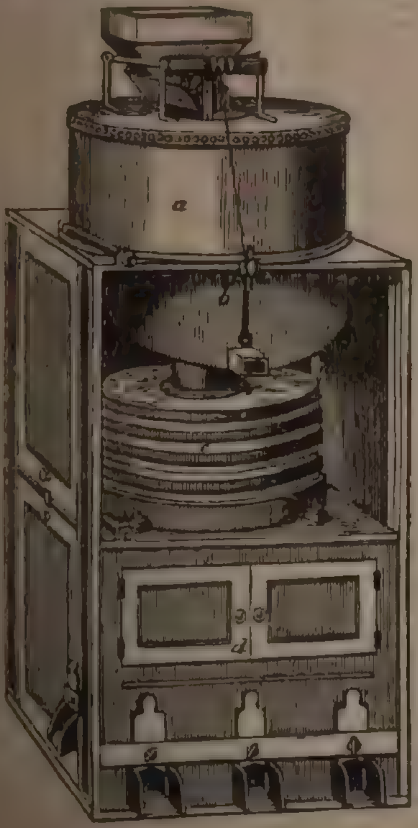


The spindles of the mill-stone are supported on the iron levers *m m*, which can be raised or lowered to adjust the stones, by means of regulating screws at *n n*; *o o* are screws to raise the pinions *e e*, and cast them out of geer. The under, or bed stones, are partly sunk into circular holes in the platform, and firmly wedged therein, and a circular case incloses each pair of stones, leaving a space of about two inches all round them; and the corn, reduced to the state of meal, is thrown, by the centrifugal force of the stones, out in all directions into the case, from whence it is conveyed to the bolting machine, which is driven by a band from the drum-wheel *t*. The bolting machine is not shown, as the reader will find a description of an improved one under the word BOLTING-MACHINE.

In grinding wheat, it is usually the endeavour of millers to separate all the flour from the husk without pressing it so hard as to *kill it*, and without deteriorating its colour by making minute *greys*. This they have not been enabled to effect in a desirable manner with the mills constructed on the usual plan, nor by any form of construction that has hitherto appeared. The reason is obvious;—if the stones be brought so close together as is necessary to remove the firmly adhering portions of the flour from the husk, the whole of it will be, in a great degree, *killed* and discoloured by the violent rubbing necessary to clean the bran; on the other hand, if the stones are kept further apart, so as to *grind high*, much of the flour will be left in the offals and bran.

With a view of meeting these difficulties, some millers have ground their wheat at two distinct operations: they have, in the first place, set their stones wider apart, or *grind high;* and then, after collecting the meal, and separating the fine flour from it, have passed the remainder a second time through the stones, setting them closer than before, or *grinding low.* Thus have they removed the whole of the flour from the husk, and preserved the good quality of a part of it; but the waste, and loss of time and power in conveying the meal from one place to another, occasioned by these several operations, together with the difficulty of separating the flour from it in the unfinished state by the ordinary dressing machine, have been found to neutralize the advantages otherwise resulting from this mode of proceeding.

In consequence of the great size and weight of the stones usually employed, the erections and fittings up of the ordinary mill are necessarily very heavy and expensive; and, owing to the several processes of grinding, cooling, dressing, and clearing up, being distinctly conducted in situations remote from each other, a considerable waste of flour, together with much unnecessary manual labour, and waste of mechanical power, are incurred. These disadvantages, which are inseparable from the old system, are completely obviated by the patent progressive corn-mill, manufactured by Messrs. Cotterill and Hill, of Walsal, in Staffordshire, from the following causes:—Instead of employing only



a single pair of stones of great weight and diameter (by which a large portion of the flour that is formed near the eye of the stone has to pass, with the bran,

over a greater extent of surface than is necessary, thus injuring it by friction, besides expending the motive power for the purpose, the progressive mill is provided with two pair of stones, of smaller diameter; underneath the first pair (shown in the figure, as in the case at *a*) is inspected and agitated a circular sieve *b*, which receives the product as it falls freely from the stones, and separating that portion of the flour which is sufficiently reduced or *softened*, it delivers the unfinished portion into the eye of the second pair of stones underneath, shown at *c c*, with their case removed, as well as one of the external shutters which inclose the whole machine when at work. This second pair are set closer together than the first, to complete the softening of the remainder of the meal, which, in consequence of the bulk of the flour being separated from it, will be much more easily operated upon, and, at the same time, effect a saving of power. Underneath this pair of stones is placed, inclosed in its case, a dressing-machine, with brushes, which receives the meal from the stones as it is ground, and separates the remaining flour, as well as the different qualities of offals. When several progressive mills are employed, the meal resulting from the second pair of stones in each mill may be advantageously conducted into one dressing-machine, common to them all. In consequence of this division of the grinding operation into two stages, and the small size of the stones employed, the meal is not heated. This, together with the important circumstances of the bulk of the flour being separated from it, in the first instance, without bruising, renders the remainder fit for dressing up as fast as it is ground. By this arrangement, therefore, it will be readily perceived, that the original colour and strength of the flour is preserved; that all the flour is separated from the bran without any injury to the bulk of it; and that the whole process of grinding, dressing, and clearing up the offals, is one continuous operation, performed in one compact machine, without waste, and with little manual labour.

The progressive mill is made principally of iron, and so arranged and fitted together, that, while the nicest accuracy in its adjustments, and certainty in its operations, are insured, the stones may be taken up to be dressed, and put down again with the utmost facility and ease. Its parts are readily taken to pieces, so as to make it easy of conveyance; and in consequence of all of them coming together with metallic faces, it can be properly re-connected by the common workman; and from its compactness and portability, it is peculiarly adapted for exportation, as the entire mill can be packed in a strong case, and the weight of it is very little more than the stones alone of a common mill doing the same work.

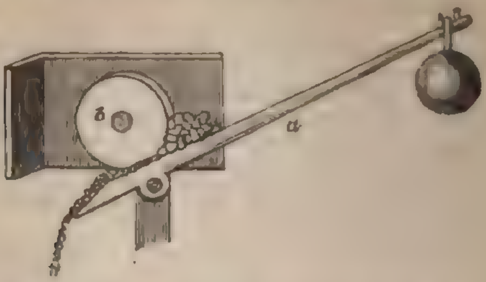
MINE AND MINING. Mine is a term applied to works carried on under ground, for obtaining minerals generally, but chiefly for metallic ores. The internal parts of the earth, as far as they have been investigated, consist of various strata or beds of substances, extremely different in their appearance, specific gravities, and chemical qualities, from one another. Neither are the strata similar to one another in different countries; and in one district, the same varies considerably in its nature, at very short distances apart. Rocks of all kinds are traversed in every direction by cracks or fissures, having, in many instances, the appearance of those formed in clay and mud while gradually becoming dry in hot weather. These fissures are in general filled with substances formed of materials differing from the rocks in which they are situated. When they contain minerals partly composed of any kind of metal, they are called metallic *veins*, *lodes*, or *courses*. Metallic veins are only found in what are called the primitive rocks, as granite and slate; and, in general, their course is from east to west. A vein rarely consists of metal in a pure and malleable state, but is almost always found in chemical combination with other substances; in this state it is called an ore, the metal of which is separated by the process called *smelting*, which is, in fact, a melting-out of the metal from its combinations, usually effected by the addition of such foreign substances as will, by their chemical affinities, assist in the separation of the metal. The thickness, extent, and direction of a vein of metal, depends on many circumstances; in general, its course downwards is in a slanting direction, more

...ised; if it continues in a straight line, and of a uniform thickness, it ... a *rake*; if it occasionally swells out in places, and again contracts, it ...d a *pipe-vein*, and the wider parts of the vein are called floors; some... vein divides itself into branches, and then it is said to *take horse*; in ...es a cross grain will interfere with it, and heave or lift it, as it were, ... to 20 feet out of its course. At times it will be reduced to a mere ...and at last become completely obliterated, appearing again at a dis... In many of these cases the difficulty of tracing these precious deposits ... their rocky labyrinths must be evident. In all probability, however, ...ls were at first procured from detached fragments of the ores, such as ... separated from the upper parts of the veins in which they were origi...posited; and in this manner is gold yet procured, by washing the sands ... rivers. The pursuit of these scattered pieces of ore would naturally ... the persons thus employed to the beds from which they had been ..., and in turning over the soil to procure the loose fragments, the backs ...eins would be laid open and discovered.

...n of Cornwall was the first metal sought after in Britain of which we ... historical account; but the traces of the most ancient tin-works exhibit ...toms of their having been pursued but in situations where the soil with ... was mixed could be easily removed, or where the ore could be laid ...conducting over it streams of water to carry off the lighter parts of the ...ad is often found near the surface of the earth, and as the ores gene...hibit a metallic appearance, that metal was probably an early object of ... but it was not until machines were invented to pump away the waters, ... gunpowder had furnished the means of splitting the hardest rocks, ... was enabled to penetrate strata of every description that opposed his ... These inventions, therefore, form most important epochs in the his...mining. The hammer and wedges were probably the first instruments ...d for splitting rocks, and the pick followed, which is used both as a ... and a wedge. Previously to the use of iron, wedges of dry wood were ... of by driving them into clefts of the rock, and then wetting them, so ...e them to swell and force the parts asunder. The means employed ...g up the minerals to the surface were at first extremely rude. The ... and bucket may be reckoned an improvement which took place in a ...r of mining. This simple mechanism had its origin in Germany; ...e it was introduced into this country, the mode adopted here was by ...uccessive stages, upon each of which men were placed, who raised the ...l matter from one to the other until it reached the top, in the same ... is now commonly practised in digging out the foundations for houses, ...aking deep drains. In South America the ores are for the most part ... by the Indians; and where the situation admits of sloping roads, on ...s of mules. To Germany may also be traced the introduction of ... machines for raising the water constantly collecting in the mines. ...ere adapted to the shafts, and their constant action secured by giving ... their pistons by wheels turned by descending streams of water. To ..., however, belongs the merit of having greatly improved the pump... the water-engines to their present effective condition; and by the ... application of the steam engine to this purpose, the mining processes ...ntrymen have so far surpassed those of other countries, as to render ...ion indispensable in most situations.

...gh copper is now the greatest metallic product of the county of Corn... is comparatively, to the other metals, of modern discovery, not ...en worked longer than a century. The reason assigned for its having ...mained concealed, is the assumed fact, that copper generally occurs at ...reater depth than tin; and that, consequently, the ancients, for want ... machinery to drain off the water, were compelled to relinquish the ... vein before they reached the copper. It is stated by Pryce in his ... *Cornubiensis*, as a general rule, that tin seldom continued rich and ...king lower than 50 fathoms; but of late years the richest tin mines ...wall have been much deeper. Trevenen mine was 150; Hewas

of water constantly passing through the mass, and washing away the pa[rt] which is sufficiently reduced to pass through the holes made in an iron p[late] which forms one side of the box in which the stampers work.



The next operation is that of *jigging;* this used to be performed entirel[y by] boys, and consists in shaking a quantity of bruised ore in a kind of sieve, [with] an iron bottom to it, while under water. This occasions the heavier parts, w[hich] consist almost entirely of metal, to sink to the bottom; while the earthy m[atter] is washed away, and the small fragments of stone, being lighter than the [ore] and containing little or no ore, are left on the surface in the sieve; the[se are] carefully skimmed off with the hand, and the remainder is piled up in h[eaps] for sale. This process has been recently considerably improved by Mr. Th[omas] Petherick, a mine-agent, of Penpellick, who took out a patent in 1830, [for] machinery for separating copper, lead, and other ores from earths and other [sub]stances with which they are and may be mixed, and is more partic[ularly] intended to supersede the operation now practised for that purpose, comm[only] called jigging." This machinery is thus composed; namely, a large vat or [cistern] with a fixed cover, in which cover are apertures and receptacles adapted t[o the] form and size of a number of sieves, such as are used in the operation of [sepa]rating copper, lead, and other ores, from the substances with which the[y are] usually mixed. The vat is filled with water, and the sieves with the min[erals] in them are placed in their receptacles, so as to be immersed in the water [con]tained in the vat; the interior capacity of which communicates with the in[terior] capacity of a hollow cylinder; into this a plunger or piston is fitted, whi[ch is] moved alternately up and down within it, so as alternately to displace [water] therefrom, and force the same into the vat, and then withdraw water fro[m the] vat into the hollow cylinder; thus causing a sudden flux and reflux of the [water] through the sieves, which is continued until the required degree of sepa[ration] of the earths from the ores is effected.

In the specification of a second patent, granted in 1832, to Mr. Pether[ick, in] conjunction with Mr. Kingston, of Islington, in Devonshire, for improve[ments] in the patent machinery just described, it is directed that the aforesaid cy[linder] is to be provided with a bottom plate and foot valves, opening outwards to [allow] the escape of the water into the vat, but not to permit its return; and th[e pis]ton is furnished with valves opening downwards to allow the water t[o pass] through it in that direction, so that the motion of the piston shall cau[se the] water to pass through the cylinder the same as in a common lifting [water] pump. By this improvement, the water instead of being made to pass u[p and] down through the sieves, containing the minerals, as in the previous pl[an, is] forced through the sieves by a series of impulses varying in extent and in[tensity] with the proportion of the area of the piston to the areas of the sieve[s, and] the extent and rapidity of the motion communicated to the piston. Th[e first] mover of this machinery may be steam, or water, or horse, or man pow[er, as] circumstances may demand. It is proposed by the patentees as one mo[difica]tion of their plans, to carry a shaft from a first mover over a series of sep[arate ...] placed in a row, and made to actuate each piston, by means of a [...]

addition to this the miners receive a small per centage on the ores, in order to induce them to keep the valuable portions as separate as possible from the *deads*, or rocky parts of the mass.

In addition to these horizontal and perpendicular shafts, another description of gallery is formed, called an *adit*; the use of this shaft is to drain the water from the lower parts of the mine. Where the mine is formed in an exposed rock, as in the Botallick mine, in Cornwall, the adit can carry off the water without the aid of machinery, as long as the lowest shaft is above the level of the sea; but when the shafts are sunk below that level, or that of the adit itself, recourse must be had to the assistance of steam-engines to pump up the drainage to a sufficient height. The great Cornish adit, which commences in a valley near Gwennap, receives branches from fifty different mines in the parish of Guennap, forming altogether an excavation nearly thirty miles in length. The longest continued branch, is from Cardrew mine, five and a half miles in length; this stupendous mine empties itself into Falmouth harbour.

The lode, when divided as above described, is open to the inspection of all the neighbouring miners in the country, and each mass or compartment is let by public competition for two months, to two or four miners, who may work it as they choose. These men undertake to break the ores, and raise them to the surface, or as it is termed *to grass*, and pay for the whole process of dressing the ores, that is, preparing them for market. The men by whom the mines are worked in this manner are called *tributers*, and their share of the value of the ore, which varies according to its richness in metal, is named *tribute*. This tribute is paid over to them every week, the mineral being disposed of at a *ticketing*, or weekly sale. In addition to the working miners, a set of men, whose experience entitle them to the office, are engaged at a stated salary, to act as overlookers, and direct the labours of the rest; those whose business lies in the mines, are called *under-ground captains*, and those employed above ground *grass captains*. The weekly produce of the mine being made up by the dressers into heaps of about one hundred tons each, samples, or little bags from each heap, are sent to the agents for the different copper companies. The agents submit these to the Cornish assayers, a set of men, who (strange to relate,) are destitute of the most distant notion of the theories of chemistry or metallurgy, but who nevertheless can practically determine, with great accuracy, the value of each sample of ore. As soon as the agents have been informed of the assay, they determine how much a ton they will offer for each heap of ore at the weekly ticketing. At this meeting, all the mine-agents, as well as the agents of the several copper companies, attend, and it is singular to see the whole of the ores, amounting to several thousand tons, sold without the utterance of a single word. The agents for the copper companies, seated at a long table, hand individually to the chairman, a ticket or tender, stating what sum per ton they offer for each heap. As soon as every man has delivered his ticket, they are all ordered to be printed together, in a tabular form. The largest sum offered for each heap, is distinguished by a line drawn under it in the table, and the agent who has made this offer is the purchaser.

In order to prepare copper ores for market, the first process is to throw aside the rubbish, with which they are unavoidably mixed; this task is performed by children. The largest fragments of ore are then *cobbed*, or broken into small pieces, by women, and after being again picked, they are given to what the Cornish miners term *maidens*, that is, young girls. These maidens *buck* the ores, that is, with a bucking iron, or flat hammer, they break them into pieces not exceeding half an inch in size. The richer parts of the ore, which are more easily broken, are now crushed smaller in a kind of mill, the principle of the construction of which is shown in the diagram on p. 162; where *a* represents a weighted lever, by the depression of which the ore between it and the roller *b* becomes crushed; and on the raising of the lever, the crushed ore falls away, and a fresh portion of ore is thrown into a position to receive the pressure upon the succeeding depression of the lever. The coarser portions, which are the hardest, are bruised in a *stamping mill*, in which heavy weights or hammers are lifted by cams on a revolving shaft, and allowed to fall upon the ore, a stream

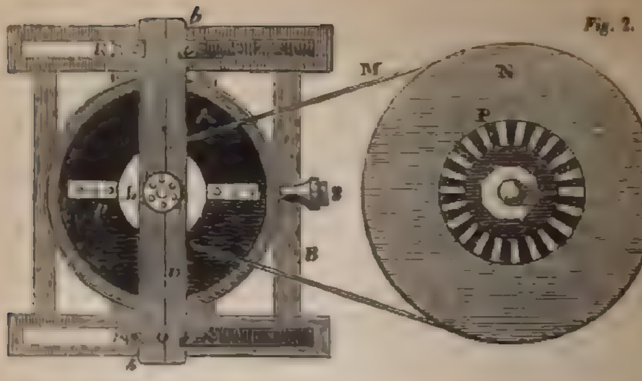


Fig. 2.

a detailed description of his apparatus, prefacing our account with the observation, that its application is not confined to the more precious metals, but may be advantageously employed in the separation of other solid substances of dissimilar specific gravities. If the matrices in which metals are found are of a hard and stony nature, they must, in the first instance, be reduced by hammers, or by the operation of an ordinary stamping-mill, to powder or dust; for the smaller the particles are, the more effectually will they be separated by the subsequent process. The materials so prepared are put into a deep conical or cylindrical tub, with a quantity of water sufficient to permit the whole of the ore, soil, or other powdered materials, to float about in a perfectly free and liquid state whenever the water is stirred round by the agitators, which we shall presently describe; and with a force and velocity so as to drive the water up the sides of the tub in such manner, that a hollow space, in the shape of an inverted cone, may be formed in the water within the tub. *Fig.* 1 of the previous engravings, is a side view of the apparatus; *Fig.* 2 a plan of the same; and *Fig.* 3 a section of the tub, to show the form of the agitator, and the means used to suspend and move it; the same letters of reference are used to denote the same parts in all the figures. A is the tub, quite smooth in the inside, supported upon a platform B, forming a part of the frame of the machine, and from which the two standards, C C, rise that support the horizontal cross-frame D D, which carries the agitator F G H I. This agitator may be made of wood or iron, according to the magnitude of the machine, and consists of four double arms F F F F, which support and carry the stirrers I I I I, which hang vertically. These stirrers may be screwed or morticed into the double arms F F F F, which are in like manner screwed or morticed into the strong central block G; through the centre of this block (which is also the centre of the agitator), the iron spindle H passes, being fixed by a nut and screw beneath the block, and terminating at its upper end in the handle *k*, which serves to turn the agitator round; on which account the spindle has two turned bearings, which run in brass boxes *a a*. As the power and velocity of the winch K would not be sufficient in large machines, a rigger is hung at L, upon the iron spindle H, so that the agitator may be turned by a band passing round it; and round a large rigger moved by a horse-wheel (or any sufficient power) as shown in *Figs.* 1 and 2, where M is the band, and N the large rigger fixed upon the vertical shaft O, the bevel pinion of which at P takes into the teeth of a large horse-wheel, not shown in the drawings because it does not constitute any part of the invention. By this mode of working any required number of machines can be placed round the horse-wheel, and be worked at the same time. The external bars of the stirrers I I come very nearly in contact with the sides, and their extremities very near to the flat bottom of the tub, so as to insure the

-l the whole quantity of
that may be mixed with
, and prevent, as far as
he deposit of any part of
either on the bottom, or
ides of the tub; and for
djustment of the ends of
es to the bottom of the
orizontal cross-frame D D
es up and down in long
grooves, made for that
, Q Q, near the tops of
standards C C, (as dis-
s in *Figs.* 1, 2, and 6,)
ed at the required height
of the iron screw-bolts
h pass into any of the
holes made in the side of
rds, *Figs.* 3 and 5. A
elevation of the agitator
mes, be necessary in first
e machine to work, if the
d ore or sand put into the
f such a dense or heavy
to prevent the agitator
ing; while, by lifting it
t instance, and then set-
motion, and afterwards
it gently while in motion,
radually lay hold of the
, and soon put them into a
motion. In the underneath
erspective figure is given
itator, detached from the
es of the machine; and
rpose of so detaching it,
frame D D, together with
boxes, are made to take
ongitudinally, as seen in
nd 2, but are bolted
whilst the machine is in
a cock, or spigot and
drawing off the water
tub whenever it may be
; in addition to this, the
the bottom of the tub is
with a peculiar valve,
nd construction of which
of the leading features
invention. This valve
different constructions,
ppear when its use has
ribed. One form of it is
section at *Fig.* 3, and
on at *Fig.* 5. In *Fig.* 3
ass or other metal cylin-
h must be bored in its
a pump barrel, in order
piston *d*, which is packed
p, leather, or other fit

Fig. 3.

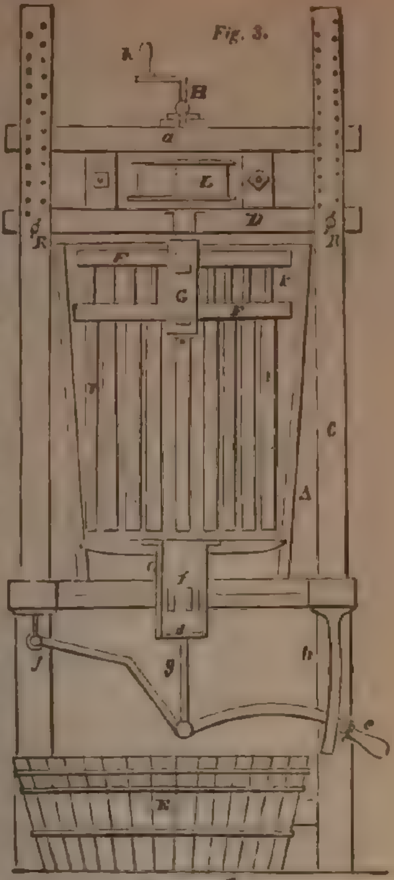
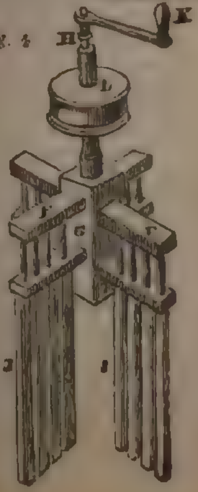


Fig. 4.



material, may move in a water-tight manner within it; *e f* is an iron lever turning on the fulcrum *f* for the purpose of moving the piston with which it is connected by the rod *g*; and *h* is an iron loop or guide, which not only causes the lever *e f* to move up and down without external action, but also regulates and restrains its quantity of motion, which is necessary, because when the end *e* of the lever is drawn up to its highest possible elevation, the piston *d* should be at the top of the barrel *c c*, with its convex upper surface just projecting into the tub, as shown by the curved dotted line; and when the end *e* of the lever is at its greatest depression, the piston must be at the bottom of the said barrel, but must never move out of it; and when the said piston is in its lowest situation, as shown in the figure, its upper surface must be just below a row of large holes, which are formed round the said barrel as at *f f*; consequently, while the piston is in its position, any fluid that may happen to be in the tub will flow out of it, through these holes, into a shallow tub E, placed underneath to receive it, but if the piston is raised rather more than its own thickness, it will cover all the said hole *f f*, and prevent the discharge of anything from the tub, although it will leave all the upper part of the barrel *c c* open, as a well or receptacle to receive anything that may fall into it; and this well, or receptacle, may, in a moment, be annihilated by pushing the piston upwards.

The other form of the valve, shown in *Fig* 5, is similarly placed in the centre of the bottom of the tub, and for the same purpose, though rather more simple in its construction. It consists merely of a conical brass or other metal stopper, turned and ground, or packed so as to fit tightly into the hole of the metal plate *t t*, which is let into the bottom of the tub: this stopper is moved, as in the former valve, by the iron or metal lever *e f*, and attached to the plug or stopper by the iron rod *g*, so that the valve may be opened or shut at pleasure, by applying the hand to the end of the lever. It will be observed in all the above figures, and particularly in the perspective view of the agitator at *Fig.* 4, that there are no stirrers I I I in the centre of the agitator, but that a certain space, fully equal to the size of the central valve, is left free for them, not only for the purpose of permitting the valve to rise between the stirrers, but also to prevent the same degree of motion being given to the central part of the contents of the tub, that is given to the sides of it. Having so far described the general form and construction of the apparatus, we shall next proceed to describe the manner of using it, for the purpose of extracting the gold, silver, or other metals or materials, from the sand, earth, or other matrices with which they may happen to be mixed. For this purpose the tub A A must be about half filled with water, or, what is better, may communicate by a pipe, shoot, or trough, with water, which can at pleasure be permitted to run into the tub, or may be stopped; the cock S and central valve being of course closed at this time. The ore and matrice, or other material to be operated upon, reduced to a state of powder, must now be thrown in, in such quantity that it will not exceed in weight more than about half the weight of the water in the tub at any one time; but a greater or less quantity may be added, according to its density, which will be easily ascertained by practice. The agitator is then to be put into motion, beginning slowly at first, but quickening it until the whole quantity of water, and the materials that have been thrown into it, are put into rapid motion, and the whole of the ore, or other material, however heavy, has become completely incorporated with, and floats in, the water. It will soon be found, that the water, by its centrifugal force, will rise against the sides of the tub, and leave a hollow space in the middle of it, in the form of an inverted cone, as shown by the dotted lines *k k k k*, in the section of *Fig.* 3. This effect takes place to such an extent (if the height of the tub and the size of the agitator are properly proportioned to one another, and the motion is sufficiently rapid), that the central valve at the bottom of the tub can be distinctly seen from above, and may even be opened without danger of discharging much of the water; and if, after continuing this rapid motion for two or three minutes, it is gradually abated, and the agitator is brought to a state of rest, it will be found that all the gold or silver, or other metals, so mixed with the water, will

posited in a heap in the centre of the tub, immediately over the centre

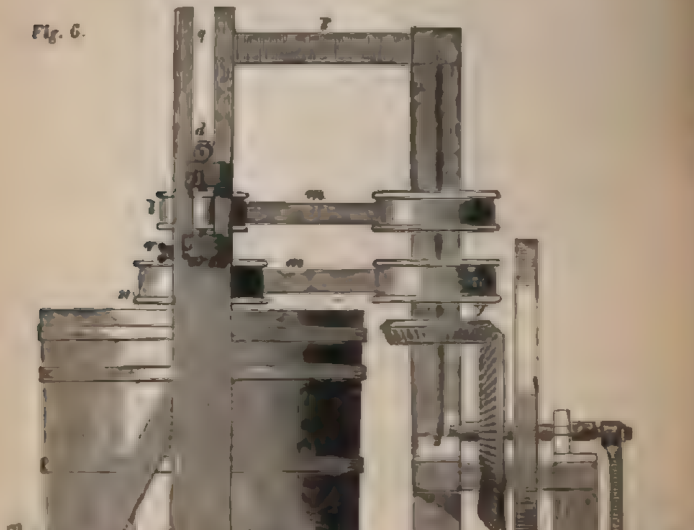
..h very little admixture of the sand or earth that was previously mixed ..nd, consequently, if the piston *d* of the tub-valve in *Fig.* 3 is lowered, ..rm the chamber or cavity, at the same time that the motion of the .. slackened, such heavy material will be deposited in the said chamber .. and may be drawn off with a little of the sand, earth, and water ..ying it, into the receiving tube E, by lowering the said piston below ..described at *f f f* in the figure; but if the discharge should be followed ..uch sand, earth, and water, it may instantly be stopped by raising the ..ve the holes. Should the ore or other material not be sufficiently ..deposit itself in the centre of the tub, then the stopper valve, shown ..is to be used in preference, which is not to be opened until the fluid .. has been moved for a minute, and the central hollow cone is formed ..ddle, when the stopper may be raised, and the speed of the agitator ..d, until the water begins to flow gently from the valve, when, in ..it will bring the ore, or other heavy materials with it, and must be

Fig. 5

.. to run so long as this is the case; the valve is then to be closed, and ..r again put into rapid motion; after which the valve is to be again ..nd so in succession, until the whole of the ore, or other heavy mate- ..ained, which will be known by its ceasing to run from the lower cen- .. when the remaining refuse is to be drawn off by opening the valve .. S, having previously placed another tub, called the waste-tub, under ..ne for the purpose of receiving it; and while so running off, the ..ust be kept in motion to stir it up and wash out the contents of the ..n empty, the waste-tub, with its contents, must be removed, and the ..ust be supplied with a fresh quantity of water and ore, or other ..rial, to resume the operation.

From the foregoing description of this machine in its most simple state, it will appear, that a much less proportionate quantity of motion takes place near the centre of the agitator, than near its outside, particularly when the machine is made on a large scale, on which account it is necessary, in large machines, to construct a double agitator, that is to say, one in which the central part turns or moves with greater velocity than the external part, as shown in section at *Fig.* 5, where I I I I F F show the agitator constructed as before, except that its arms and stirrers are more extended from the centre, so as to make room for the smaller central agitator *i i i* which may be constructed in the same way as before described, or may have its stirrers fixed into the circular block of wood or metal *j j*, and the iron axes, instead of being fixed into the central block G, now passes through it, and is fixed to the small or internal agitator. For this purpose, the central block G of the agitator should be lined with a brass box, or have proper bearings upon its ends, so that it may revolve freely upon the iron spindle H; it has also a bearing at *n*, in the lower part of the cross frame D D, to assist in supporting it; and on account of the greater weight that now hangs on the said iron spindle H, two friction wheels are fixed to its upper end, as at *o o*, which run upon the top of the brass bearing *p*, and materially diminish the friction. When the double agitator is used, two riggers will be necessary, as at L and W, and the one at W, which communicates with the large external agitator, is made double the diameter of the smaller one L, which is fixed upon the iron axle H, in order that the small internal agitator may move with double the velocity of the large external one. In every other respect, this

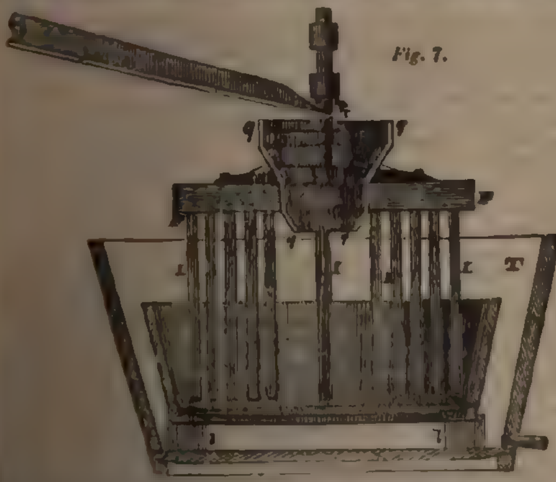
Fig. 6.



machine is the same as the one already described. *Fig.* 6, is an elevation of a machine, with a double agitator introduced, merely to show how such a machine, on a small scale, may be moved by hand. *l* and *w* are the two riggers of the [illegible] and external agitators, as in the last figure, and motion is commun

them by the bands *m m*, which pass round the two riggers *v* and *u*, the same diameter, and both fixed upon the upright iron shaft *x x*, also carries the bevelled wheel *y*, which is driven by the larger wheel Y, on the main shaft, which also carries a heavy fly wheel *z z*, and the handle by which the whole is turned. The timber framing *t t*, for the said wheel and riggers, is too obvious to need description, and may in form, to suit the convenience of the place in which the machinery ; and when a horse is adopted for machinery of magnitude, it needless to observe, that it must take into, and drive the wheel *y*, this purpose may be fixed higher on its shaft, when the wheel *y*, with eel, shaft, and handle, will be unnecessary. In the use of this machine, to expect to get the ore or other heavy material, separated from the th, or other material, with which it may be mixed, in a clean and ate, by one operation as hereinbefore described, because a considerable of sand and earth will inevitably run off with it in the water. The oposed by the patentee therefore is, to save all the first portions that om the central valve at the first washing, in a tub or other receptacle by es; and when a sufficient quantity is thus accumulated, it is to be again machine, which may be smaller for this purpose, and it is to be treated in the same manner as the crude materials in the first instance, when further cleansed and purified; but if not in a sufficiently clean state second washing, it must undergo a third, or even fourth, in the same r hand machines, according to the purity required; which by due and care to the directions herein given, and a little practice, may be carried extent required. It is also necessary to observe that the operation of and separating ores, or other heavy materials, by the machinery before d, may be effected, (though in a less convenient manner,) without tion of either of the bottom central valves, or any valves at all; because vy materials, if not permitted to escape by the valves, will accumulate p in the centre of the tub, and will be found upon carefully removing earth, or matrice from around about it; or another process may be h as the apparatus delineated in the subjoined *Fig.* 7, is adapted for,

Fig. 7.



ere a shallow tub is set within a deeper and larger one T, either with the blocks *l l* to raise it above the bottom of the exterior tub; or the may be fixed in a running stream, or a stream may be made to run ly into and out of it. When the apparatus is arranged in this form, ing motion of the agitator F F I I will have the effect of throwing the water that is introduced with the ore into the shallow tub, over its

edges into the external tub, or into the running stream, (as the case may be,) or into a reservoir; and with it nearly all the sand, earth, or matrice will be thrown over, so as to leave the ore, or other heavy material, in a nearly clean state at the bottom of the tub, particularly if a sufficient quantity of water has been used during the process.

The whole agitator is now to be removed, for taking out the clean ore, and when an accumulation of refuse has taken place in the outer tub, (if such a one be used,) the inner one is to be removed, and the agitator lowered into the other large tub for stirring up the said refuse and water, while it is drawn off by the plug, or spigot and fauset at S; after which such refuse and water are to be again passed through a machine by way of examination, to ascertain if any ore, &c. had passed over with it; and if so, it will be obtained at this second washing. The refuse and water might be led over coarse flannel or cloth, in which the heavy material would deposit itself, if there be any left in the refuse. It may likewise happen in some cases, that the ore, or other heavy substances, cannot be conveniently broken down and reduced to powder, but may contain diamonds, precious stones, lumps, or fragments which would be too large and heavy to be put into motion with the water, as before described; whenever this is the case, the construction of the agitator, shown in *Fig.* 7, is recommended, which in effect is the same as those already described; but instead of intersecting the arms F F, which carry the stirrers I I I into the central block of wood already described, a circular kind of funnel or hopper is constructed as shown in section at *g g g g*, of iron, and the spindle revolves into transverse pieces *m m* within the said hopper; such pieces being placed with their thinnest dimensions upwards, so as to cause as little obstruction as possible. This hopper is to be fed with ore (previously broken into small pieces), by means of the shoot *n n*, which may be shook by joggles at *r*, like a cornmill, or be fed by any other convenient method. *Fig.* 7 also shows another form of the agitator. A double set of arms to carry the stirrers, is not essential; all that is necessary is, that it should possess sufficient strength and substance to put the whole of the water and heavy materials mixed therewith, into a sufficiently rapid motion, to produce the conical hollow space similar to *k k k*, *Fig.* 3, as before described.

In addition to the several modes of working the apparatus explained, it is proposed to work the same in streams, or ponds, where gold-dust, ores, &c. may be found, or suspected to exist, without using a tub, in which case the agitator only is to be used, and must be supported, as before, by its cross-bearers D D and standards C C. *Figs.* 1, 2, 3, 5, 6, being either fixed to the bottom of a boat or punt, or supported between two boats or punts, the same being immovably moored or fixed upon the water; or the machinery may be placed upon a stage with legs, adjustable to the depth of the water, so that the agitator may be put into rapid circular motion as before described; or as near as possible to the bottom of such river or stream, when it will soon, by such motion, remove the soil (provided it is not too hard or strong), and will form itself into a circular hollow space equal to its own diameter, into which space it is to be gradually lowered as the earth is washed away; when, if any gold-dust, ore, or heavy metals are present, they will be brought to the centre thereof as effectually as if the first agitator had been worked in a tub; which done, the position of the central spindle of the agitator is to be worked as accurately as possible, either upon the stage that supports it, or by placing upright straight rods in the ground round about it, when a light metal tube, of tinned or plate iron, open at both ends, and of equal diameter to about one-fourth of the agitator that has been used, is to be lowered over the said central spot, for the purpose of confining and covering whatever may have been so brought to the centre, which may then be raised in the tube, by inserting a pump therein till it reaches the sand; and after having made with it a partial vacuum by raising this pump, the whole tube is brought out with it; or by means of proper ladles, augers, screw-worms, or other implements used for boring the earth, and bringing up the same through tubes for well-sinking, and other well-known purposes; or the implement shown at *Fig.* 8 may be used to advantage. It consists of an hexagonal, or other polygonal pipe of iron made nearly to fit and

inside of the light pipe before mentioned (directed to be lowered for
securing the materials); its lower end is to be formed into as
as the first polygonal has sides, as at
. 8; these points should be of steel, not
ability, but that they may bend inwards
open again in the form shown at X, in
the pipe is to be lowered into the tube
tioned, and it must be pushed through the
tever the agitator may have brought to
by slackening and turning it round;
the same time, the central chain which
ites by branch chains with each of the
as seen at Y, is to be strained with suffi-
either by the lever Z or in any other
ng all the first points *a a a*, &c. together, in
they will be retained, until the contents
d to the pipe are brought up out of the
discharged on the boat or platform.

ow described a variety of processes for
the ores of copper, lead, tin, gold, silver,
her metals, we will refer the reader to the
, (Vol. I. pp. 374 and 375,) where a sectional engraving of a coal
n mine is given, with an accurate description of the mode of work-
. It is an astonishing and highly interesting sight to a stranger in
urhood of Birmingham, and in other coal and iron districts, to
e view, a great number of steam engines, with all their massive
nd apparatus, simultaneously at work in the open air; some employed
p the iron ore, others coal; which, as they emerge from the earth,
es lifted upon an elevated rail-road, from whence, by their own
y the aid of machinery, they are conveyed with rapidity to their
, the contents are instantly discharged, and the emptied skip brought
inuous succession.

M. A name which was given to what is now called *cinnabar*; it is a
ral, of a shining red colour, out of which quicksilver is extracted.

The place in which the king's money is coined. Formerly mints
lmost every country, for notwithstanding the coining of money
ll times to have been considered a special prerogative of the crown,
inces ceded the privilege to their subjects to a great extent, reserv-
ame time eight mints for the City of London. This arrangement
d by the Norman kings with little alteration until the period of
who procured from the east of Germany, persons well skilled in the
urpose of improving the coinage. From this time to the accession
II. A. D. 1307, but small progress appears to have been made.
however endeavoured by introducing many alterations in the con-
the mint, to improve the coinage. From this period a considerable
s to have elapsed, without any material changes taking place, until
ment of a Committee in 1798, to consider the establishment and
of his Majesty's mint, the result of which was the erection of the
t on Tower Hill, between 1805 and 1810, with highly improved
and increased facilities for carrying on the process of coining exten-
dvantageously. The various chemical manipulations necessary for
e metal to its due degree of purity previous to coinage, it is not our
nter into; we shall, therefore, proceed to a description of the dif-
sses of coining, after the metal has been received in the melting
usual mode was to melt the silver in black lead pots, and a consi-
age of tokens for the Bank of Ireland was produced in this man-
portations being entirely Spanish dollars, and the tokens of the
d, the melter could easily melt them in quantities of 60 lbs. troy,
ion. But the inconvenience of this mode was ultimately severely
ingots of silver of different qualities could not be used for coinage,
culty of blending several together in one pot to produce the proper

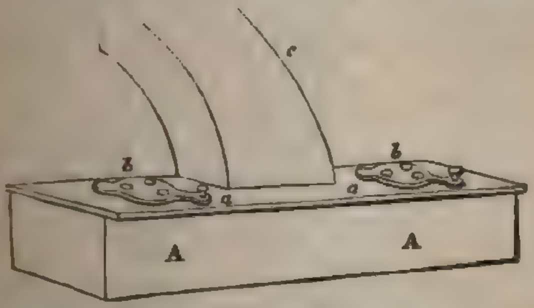
standard of our money. This obstacle was so severely felt that, in 1777, Mr. Alchorne, then principal assay master, was commissioned by Government to visit the mints of Paris, Brussels, Rouen, and Lille, for the purpose of collecting information with respect to the arts of coining as practised in those mints, and more particularly the most approved mode of melting silver in large quantities. Alchorne's intimate knowledge of the English mint, together with his great acquirements as a practical chemist, eminently fitted him for the undertaking: and his observations on the coin and coinage of France and Flanders, are alike creditable to his judgment and knowledge.

It is recorded in the documents of the mint, that at the recoinage of William III. the pots of silver weighed 400 pounds troy, and upwards, and it is somewhat extraordinary, that no trace of the process by which this was accomplished has been found; it is, therefore, mere matter of conjecture that pots of wrought iron were used.

In 1758, some trials for melting silver in wrought iron pots took place, by means of a blast furnace, but they were found so inconvenient, laborious, and profitless, as to cause the process to be abandoned. In 1787, some new experiments were tried by Mr. Morrison, (then deputy master and worker,) who conducted the meltings. A blast furnace was again tried and again abandoned. He next attempted to melt the silver in large black lead pots, containing from 100 lbs. to 120 lbs. troy; but the repeated breaking of these pots, although guarded on the outside with luting, proved a great interruption to the business, and serious loss to the melter. Trial was likewise made with cast iron pots, but these were found subject to melt, and the iron consequently got mixed with the silver. The work too was continually stopped by the king's assayer, the metal not being of the proper standard, in consequence of being refined by the process of melting, and lading it with ladles from the pot.

Great difficulties likewise were experienced in blending ingots of different qualities so as to produce the proper standard, the pots not being sufficiently large to contain the larger ingots of 60 to 80 lbs. troy, when blended together. It was therefore obvious that this mode of conducting the silver meltings was exceedingly defective, and was in consequence abandoned. Experiments were then tried with a reverberatory furnace, built after the model of those used in the Lille mint, but with no better success; and the process was, as in former cases, abandoned. The principal obstacle here appears to have been the great refinement of the silver in the melting, by the oxidation of the alloy. In 1795 and 1798 further trials were made by Mr. Morrison, for the purpose of overcoming this apparently insurmountable difficulty. In these experiments he tried three furnaces of different constructions, and although he accomplished much towards his object, there remained still a serious imperfection, arising from the process of dipping out the metal from the pots with ladles, which in addition to chilling the metal, was exceedingly laborious, and fraught with many disadvantages. In 1803 Mr. Morrison died, without bringing the process of melting silver to that degree of perfection which, had he survived, by the activity of his intellect, great knowledge of his subject, and unwearied perseverance in its prosecution, he would, doubtless, have accomplished. His son, who succeeded to his situation, appears to have inherited his father's active and intelligent mind; for in a short period he so successfully exerted himself for the accomplishment of the object sought to be attained, that by the construction of a furnace adapted for the use of cast-iron pots, the use of pots of a size capable of melting from 400 to 500 lbs. troy at one charge, the adoption of such machinery as would supersede the clumsy and wasteful process of lading the silver from the pots when melted; and lastly, the introduction of the use of moulds made of cast iron, in place of those then used, which were made of sand, the process of melting silver, so far from being a laborious, troublesome, and expensive process, became simple, and efficient in operation, and capable with ease of melting [illegible] lbs. troy of silver daily. The illustration opposite exhibits a perspective view of the furnace at present in use. A A are the furnaces in which the metal is melted. These are the air furnaces, built of fire brick, in the usual manner of melting furnaces, but to render them more durable, the brickwork is cased [illegible], which are put together by screws. *b b* are the covers to the fur-

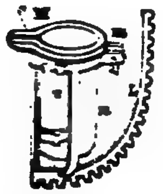
ners; they are held down to the top plate by a single screw pin for each, and on the opposite side of the cover a handle *a*, is fixed; by pushing this handle, the cover is moved sideways upon its centre pin, which leaves the furnace open; a roller is fitted to the cover, to run upon the top plate, and render the motion easy. The interior of each furnace is circular, 30 inches deep, and 21 in diameter; the bottom is a grate of cast iron bars, movable for the purpose of admitting air. Upon the grate is placed a pedestal or stand of cast iron, of a concave shape, covered an inch thick with coke or charcoal dust, upon which the melting pot is placed; the pedestal is nearly two inches thick, and is fully two inches broader in diameter than the pot, the object of which is to protect the hip of the pot from the intense heat which the current of air ascending through the grate when the furnace is at work creates, and which might otherwise melt it. On the top or mouth of the pot, is placed a muffle, which is a ring of cast-iron, six inches deep, made to fit neatly into the pot; the use of this muffle is similar to that used in melting gold, to give a greater depth of fuel in the furnace than the mere length of the pot, and which adds materially in per-



fecting the process. The muffle likewise, by rising above the pot, enables ingots of silver to be charged, which are longer than the depth of its interior. The top of the muffle is covered with a plate of cast iron, to prevent the fuel from falling into the pot, and secure the metal from the action of the atmospheric air when in fusion. Each furnace is provided with a flue, which proceeds in a horizontal direction, and extends to the flue *c* which is carried up in a sloping direction to the stack or chimney.

When the furnace-covers *b b* are closed, the current of air which enters at the grate ascends through the body of the furnace, and causes the fuel, which is coke, to burn with great intensity around the melting pot. The degree of heat is accurately regulated by a damper, fixed in the flue of each furnace. When the furnace is put to work, it is lighted by some ignited charcoal being put upon the grate, and around the pot, (for the melting pot is always in its place before the fire is lighted;) upon the charcoal about three inches depth of coke is placed; the cover *b* is shut, and the damper is withdrawn about two inches. When the coke is ignited, a similar quantity is added, and so continued until the furnace is filled with ignited coke. The object of this precaution is to prevent the cracking of the melted vessel by being too suddenly heated. Before the silver is charged, the pot is heated to a bright red: it is then carefully examined to ascertain if it has successfully withstood the action of the furnace, or cracked during the operation. The silver is then placed in the pot, accompanied by a small quantity of coarsely grained charcoal powder,—which by coating the inner surface of the pot, prevents the silver from adhering to it. When the silver has attained the fusing point, the quantity of charcoal is increased, until about half an inch thick on the surface of the silver, which preserves it in a great measure from the action of the atmosphere, and prevents that destruction of the alloy which was found so great a difficulty in the earlier processes of coining. When the silver is completely and properly melted, it is stirred with an iron stirrer, in order that the whole may be of one standard

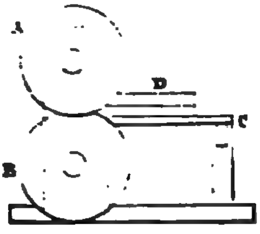
[illegible] lifted from the furnace [illegible] suspended hooks, or claws, which [illegible] raised a sufficient height from [illegible] the frame, that it may be brought [illegible]



[illegible] upper edge of the mouth [illegible] the metal. A row of [illegible] together, at the same [illegible] as the difference of [illegible] upon four wheels, and [illegible] brought in regular suc[illegible] the arched rack C is lowered [illegible] moulds are filled.

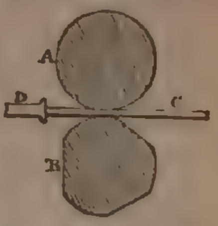
[illegible] after being taken from the [illegible] in the rolling mill. For the [illegible] of metal are heated to [illegible] is retained by the same [illegible] Gold bars do not [illegible] with great ease, to the [illegible] of cracking; this is [illegible] particles of the two [illegible] in motion by a powerful [illegible] arrangement of mechanism, [illegible] their adjacent sur[illegible] to be rolled, or flattened is [illegible] a gauge, or scale, to ascer[illegible] extension by means of [illegible] fast together at one end, the [illegible] opening between them [illegible] are divided, and as [illegible] the edge of the metal is [illegible] engraved divisions show the [illegible] After the completion [illegible] be cut into uniform [illegible] or blanks, which [illegible] crowns, two half[illegible] with accuracy and precision,

[illegible] are [illegible] the [illegible] nicety. [illegible] steel, and [illegible] any piece of metal [illegible] will be cut, or divided, in the same [illegible] of shears. C is a narrow steel [illegible] plate is supported when pushed forward to be cut; and D is a



guide, fixed upon the shelf, against which the edge of the plate of metal is applied whilst it is moved forward to the circular cutters, and which, by being moveable, determines, by the distance which it stands back from the cutting edges, or line of contact of the cutters, the precise breadth of the slip of metal which will be cut off. To give these slips of metal the exact thickness requisite before being cut into blanks, they are subject to a more delicate rolling, or are drawn between dies, by an ingenious and efficacious modification of the great rollers, invented by Mr. Barton, the present comptroller of the mint.

Mr. Barton has, likewise, brought into successful operation a new machine for drawing the metal between dies, in a similar manner to that in which wire drawing is accomplished, by which a greater degree of accuracy and uniformity is obtained in the thickness of the metal. It is, however, necessary, before this operation can be accomplished, that the ends of the slips of metal should be thinned, that they may enter, with ease, the drawing, or elongating apparatus; for which purpose they are passed between rollers, the construction of which the annexed figure will explain. A is the upper roller; B the lower, which has three flat sides; C is the piece of metal placed between the rollers, D is a stop, adjustable in the line of the motion of the slip of metal C, which is presented to the rollers when they are in such a position that one of the flat sides of the lower roller is opposite the upper, then the piece of metal can be pushed forward between the two until prevented by the stop D; as the rollers then revolve, and the flat side passes by, the cylindrical parts will take the metal between them, and roll it thinner at the end which is between the stops and the point of contact of the rollers. This thin portion of the slip of metal is then introduced between the dies, which are two steel cylinders made very hard and true. These dies are attached to one extremity of the drawing, or elongating machine, which is provided with endless chains, to which are attached tongs similar to those used in wire-drawing, which grasp the metal slip with great force, drawing it through the dies as the endless chain performs its revolution. This machine, although important in its result, and apparently exercising a great power of action, is, with but little labour, rendered available for the purpose for which it was intended, by the trifling muscular energy exercised by two boys, who conduct its operations. At the mint there are two of these machines, by means of which the pieces of metal are brought more nearly to the standard weight, which is an object of considerable importance.



The next process to which the silver slips are subjected, is accurately and efficiently performed by Mr. Bolton's cutting-out press, for which he obtained a patent in 1790. This press differs not materially from those in use at most foundries. Twelve of them are at the Royal Mint, arranged in a circle around a large wheel, which is turned by a steam engine, and has a fly-wheel fixed on the same axis, just above the wheel, to regulate the motion, the whole presenting a pleasing and commodious arrangement of machinery. The round pieces of silver, or blanks, are, after being cut out by the Bolton press, carried to the sizing-room, where each individual piece is adjusted to its standard weight. The light pieces are selected for remelting, and the heavy ones (if not considerably beyond weight) are reduced to their standard weight by rasping their surfaces with a rasp, or file. The accuracy and efficiency of Mr. Barton's machine for drawing the metal between dies, has considerably abridged the labour of this inelegant and unmechanical process. The pieces thus adjusted are in a state of great hardness from compression by the rolling and drawing processes, and by which, in fact, a great portion of their latent heat has been squeezed out. They regain their softness again by being heated to a cherry red, in a reverberatory furnace; after which they are boiled in dilute sulphuric acid, which makes them very clean, and of a white colour. When dried either in warm saw-dust, or over a very slow fire, they are in a fit state for the two next processes, which are the milling, and the coining, or stamping.

The operation of milling is performed round the edges of the pieces of mon to prevent their being clipped or filed, which was a fraud commonly practis upon the ancient money, made before the introduction of milling or letteri round the edges. The construction of the milling machine is simple, but efficaciou It consists of two rulers, or steel bars, which are accurately cut, or fluted, an by the aid of a simple combination of mechanical contrivances, so placed th although the lower one is immovable, the upper has a horizontal motion, carry ing the piece of money with it, which is placed edgeways between the two, th grooves, or flutes, in the steel bars, forming corresponding indentations an elevations, on the edge of the coin.

The next, and last operation, which remains to be performed to comple the process, is that of stamping the effigy, or impression, upon the hither blank pieces of silver. This is accomplished by the coining press, of whic there are eight in the Royal Mint. They are worked by a steam engine, whic communicates its power from an adjoining room, by means of connectin mechanical arrangements. Both sides of the piece of money are stamped b one stroke of the press. The blank piece of metal being placed flat upon th lower die, which is immovable, is then forcibly struck by the upper die, which at one stroke, produces the impression. The piece of blank coin is containe within a steel ring, or collar, whilst being stamped, which preserves its circula figure. There is, likewise, connected with this machine, a beautiful arrangeme of mechanical power, by which, when one piece of metal is struck it will b removed and replaced by another. This is accomplished through the agency the same power which puts the press in action, and consists of an arrangeme of levers and other mechanical contrivances.

The process of coining is now accomplished. Throughout this short notic we have mentioned silver as the metal coined into money by the beautiful an efficient machinery to which we have directed the attention of our reader and, by so doing, we have embraced almost every process to which the oth metals used for the same purpose are subjected; the operation, in every ca being, with a few trifling exceptions, the same. We may now truly say th the art of coining has arrived at that degree of perfection, that its furth improvement has ceased to be the object of national importance, which, earlier ages, it must have appeared. But still there cannot be a doubt, th considering the rapid strides which the physical sciences are making towa perfection, many years will not elapse before we may look back upon some those combinations of mechanical skill and ingenuity which we have been acc tomed to consider as preeminently excellent, as things which have been, hav given way to more perfect efforts, which, in their turn, may, perhaps, upon discovery of some entirely new moving power, be considered cumbrous unskilful efforts of human industry.

MIRROR. A surface of polished metal, or of glass, silvered on its poste side, capable of reflecting the rays of light from objects placed before it, exhibiting their image. There are three classes of mirrors, distinguishable their reflecting surfaces; namely, *plane*, *concave*, and *convex*. The reflect of light by mirrors observes the invariable law, that the angle which the i dent rays make with the reflecting surface is equal to the angle of reflection

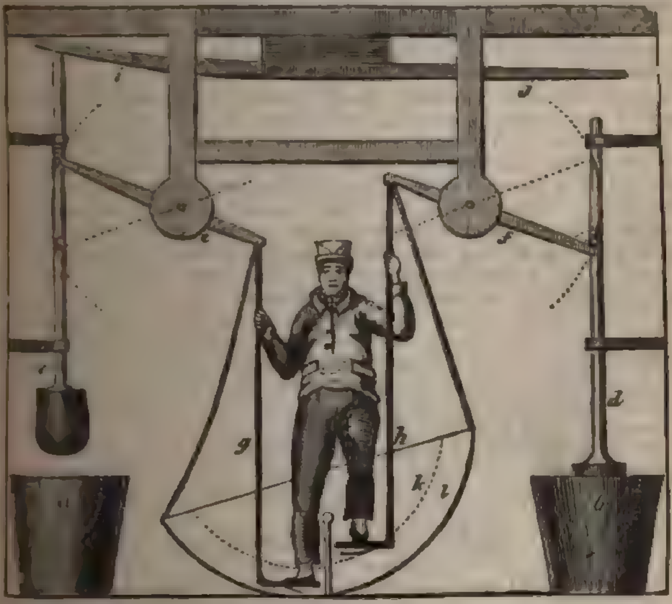
MOORINGS are an assemblage of anchors, chains, and bridles, laid athw the bottom of a river or harbour, to ride the shipping therein. These anch have generally but one fluke, which is sunk in the river near low-water m Two anchors, being thus fixed on the opposite sides of the river, are furnis with a chain extending across, from one to the other; in the middle of wh is a large square link, whose lower end terminates in a swivel, to which attached the bridles, which are short pieces of cables well served, whose up ends are drawn into the ship, and secured to the bits, &c. By these means vessel veers round easily, according to the change of the wind or the tide; some places, however, particularly on rivers, each ship takes in a bridle ast also, by which she becomes moored head and stern.

MORTAR. A cement made of lime, sand and water. See LIME.

MORTAR. A strong hollow instrument, usually made of marble, We

...d ware, or metal, in which hard or brittle substances are pulverized by percussion or grinding with another instrument called a *pestle*. Mortars usually partake of the shape of an inverted bell, but their form, capacity, and solidity, as well as the material of which they are made, vary with the object for which they are mainly designed. Thus, they may be purchased ready made, from an inch to eighteen inches, internal diameter, varying in weight, from an ounce or two, to several hundredweight. Large mortars are usually fixed upon a block of wood, of such a height, that the mortar may be level with the elbow of the operator. When the pestle is large and heavy, it is sometimes suspended by a cord or chain, attached to a moveable pole placed horizontally above the mortar; this pole considerably relieves the operator, owing to its elasticity assisting the raising of the pestle.

In the annexed diagram is represented a plan for economizing the labour of pounding and sifting, which has been recommended by a person of practical experience in those operations. *a* and *b* are two large mortars, containing the material to be reduced; *c* and *d* are the pestles, with their rods; *e* and *f* are two levers suspended at their fulcrums to a simple frame to the ceiling, connected



at one end by joints to the ends of the pestles; and by the other end, in a similar manner, to descending rods attached to treadles, which are operated upon alternately by the man in the centre stepping from one treadle to the other. In this manner a force of 150 lbs. is applied to one end of each lever in succession, and would consequently raise a similar weight at the other, if the fulcrums were in the centre. As it is however, desirable that the man should not have to step up high in lifting his weight from one treadle to the other, and as a pestle of fifty pounds weight is very considerable, those ends of the levers which are attached to the treadles are shortened, so as to make the force about 120 lbs. This loss of power, in the first instance, is however fully compensated for by the pestles being raised higher in the same space of time, or with greater velocity, and the increased momentum with which they (alternately) strike the

springs *ij*, in the ceiling, is returned by the action of the latter upon the stances in the mortars. When one of the pestles has struck, the man that treadle which operates upon it, on to the other: the long arm lever of the former then descends by its superior weight, and being near the extremity, it passes by the pin on the rod, (which should have a friction roller upon it,) by the joint opening, as shown in dotted lines, wards closing, it locks itself under the pin. In its re-ascent it then the rod and pestle, and allows them to drop when it has passed beyond sphere of its action, as shown on the opposite side, where the lever bited as being just beyond the point of contact, and the pestle is about to the mortar with all its accumulated force. Underneath each treadle, a steel spring is fixed, to prevent those shocks which the man might exp by the treadles striking against the floor, after the levers have passed the on the pestle rods; and the reaction of these springs is attended with the advantage of assisting the man on to the other treadle.

It is apparent that by this method of pounding, a surplus of power, ing to about 70 lbs. is devoted to the giving an accelerated force to the If we then take away a small portion of this surplus power for the pur sifting, it may so well be spared, as to make a scarcely perceptible differ the impelling force to the pestles. There are several obvious modes of sieves to vibrate by this apparatus. Accordingly there may be placed semicircular sieve on a floor, with cords attached to each extremity or which being made fast to the ends of the lever, cause it to rock, as th alternately raised or depressed. In the drawing, the sieve is shown as upon a central bearing or pivot; this is, however, only another mode ducing the effect. The sieve is composed of two parts; viz. *k*, which the material to be sifted, and *l*, the receptacle for the resulting pre powder. The situation of this sieve between the two mortars, for re their contents alternately, will be found convenient. It should be plac suitable distance behind or before the man at work; a rod should there fixed to the end of each lever, at right angles with them, but in an ho position, which it would always maintain; and a long range of sieves, or connected, may be moved by the same means, according to the le the horizontal rod. In the foregoing drawing, many of the subordinat which every engineer knows how to supply, are omitted to avoid compl

MORTAR. A piece of artillery, shorter and wider than a can having a powder chamber less than the size of its bore; it is used bombs and shells into fortified places.

MOSAIC GOLD. See Aurum Musivum.

MOSAIC WORK. An assemblage of little pieces of glass, marble, stones, &c. of various colours, cut to a determined pattern or des cemented on a ground of stucco, in such a manner as to imitate paintin Marquetry.

MOTHER OF PEARL, is that beautiful natural white enamel, whi the greater part of the substance of the oyster shell, particularly t oyster. It is found to consist of alternate layers of coagulated albu carbonate of lime.

MOTHER-WATER, is the uncrystallizable residue of a compound solution; thus the liquor left in a salt pan, after the salt is taken out, mother-water.

MOULD. A general term applied to a great variety of impl employed in the mechanic arts. Thus with a shipwright, a mould sig thin flexible piece of wood, on which the required curves of the tim truly cut out. *Moulds*, in the manufacture of *paper*, are the frames the sheets of paper are moulded; see Paper Manufacture. *Bullet* are similar to iron pincers in their handles and joint, but the jaws each containing a hemispherical concavity, which, when closed togeth an entire sphere, leaving a small hole or jet through which the melte conveyed. *Glaziers' moulds* are of several forms, for casting the stripe which are afterwards drawn through their vice. *Candle moulds* are used

tallow-chandlers, for casting their mould candles in. The term mould is indeed of such general application to patterns for working by, and to various tools containing hollow cavities, either for casting in or producing various forms by percussion or compression.

MOULDINGS. Any thing that has been cast in a mould, or has that appearance; in architecture, the term is applied to the ornamental projections from a wall or column, &c.

MOWING MACHINE. An agricultural implement, designed to supersede the use of scythes by hand. Many have been made at different times, but the difficulty of adapting them to the ordinary unevenness of the surface of the fields, has, we believe, caused their general abandonment; but it is not improbable they will ultimately be brought into use in many situations. In a model of one of these machines, which is placed before us, a circular knife or knives are attached to the periphery of a wheel, which revolves horizontally between the running wheels of a light carriage; the axis of the running wheels communicating the motion to the horizontal cutting wheel, through the medium of bevilled gear. The height of the cutting wheel from the ground is regulated by means of a lever and weight; and the machine is forced forward by a horse placed behind it. For mowing grass plots, a beautiful machine has been invented and matured by Mr. Budding. See GRASS in the work; also a model of the machine in the Museum of the Mechanical Arts, in Leicester-square.

MUCIC ACID. This acid has generally been known by the name of *saccholactic*, because it was first obtained from sugar of milk, but all the gums appear to afford it readily.

MUCILAGE. A general term, denoting any viscid or glutinous liquid; but chemically speaking, it is understood to apply only to an aqueous solution of gum, or mucilaginous extract of vegetables.

MUFFLE. A vessel employed in metallurgic operations. In figure it represents an oblong arch or vault, the hinder part of which is closed by a semicircular plane, and the lower part, or floor, is a rectangular plane. It is a little oven, that is placed horizontally in assay and enamelling furnaces, so that its open side corresponds with the door of the fire-place. Under this arched oven, small cupels or crucibles are placed; and the substances contained are thus exposed to intense heat, without contact of fuel, smoke or ashes.

MULE. A machine employed in spinning cotton and other fibrous materials. It was invented by Crompton, in 1779, and was found to produce finer yarn than was spun by the machine previously in use. For producing fine threads, a process analogous to that performed with carded cotton, upon a common spinning wheel, and called *stretching*, is resorted to. In this operation, portions of yarn, several yards long, are forcibly stretched in the direction of their length, with a view to elongate and reduce those parts of the yarn which are a greater diameter, and are less twisted than the other parts, so that the size and twist of the thread may become uniform throughout. To effect the process of stretching, the spindles are mounted upon a carriage, which is moved backwards or forwards across the floor, receding when the threads are to be stretched, and returning when they are to be wound up. The yarn produced by mule spinning is more perfect than any other, and is employed in the fabrication of the finest articles. The sewing thread, spun by mules, is a combination of two, four, or six threads. Threads have been produced of such fineness, that a pound of cotton has been calculated to reach 167 miles. See COTTON and SPINNING.

MULLER. A tool employed for holding or grinding substances upon a stone. The glass-grinders thus call the instrument used for grinding their glasses, which consists of a round piece of *wood*, about six inches long, to one end of which is cemented the glass to be ground, whether convex in a basin, or concave in a sphere. For grinding colours, the muller is of stone, and is usually employed upon a flat slab of stone; as may be seen in most painters' and colourmen's shops. An improvement upon this plan was, however, introduced by Mr. Rawlinson, for which the Society of Arts awarded him their

silver medal. As this machine is said to have been proved, by many years' experience, to be more effectual and expeditious in grinding colour to that extreme fineness required by artists, and to be less prejudicial to the health of the workman, we shall here add a description of it.

The machine consists of a short cylinder of black marble, 16½ inches in diameter, and 4½ in thickness, turned vertically on its axis by means of a winch. A concave piece of marble is provided, of the same breadth as the circular stone, and forming a segment of the same circle, one-third of the circumference in extent; this segment, which may be considered as the muller, is fitted into a solid piece of wood of a similar shape, one end of which is secured by a hinge, or otherwise, to the frame; the other end rising over the circular stone, and supported by it, is further pressed down on it by a long spring bent over from the opposite extremity of the stand, and regulated as to its pressure by a screw, whose end turns against the concave muller. A slight frame of iron in front, moveable on a hinge, supports a scraper, formed out of a piece of watch-spring, which takes off the colour, and is turned back out of the way when not in use.

MURIATIC ACID. See ACID, MURIATIC.

MUSK. A strong perfume, obtained from an animal of that name

MUSKET. The fire-arm of the common soldier.

MUSKETOON. A short thick kind of musket; also called a blunderbuss.

MUSLIN. A fine sort of cotton cloth, first imported from India, but now for the most part manufactured in this country.

MUST. The unfermented juice of the grape.

MYRRH. A gummy, resinous, concrete juice, which issues by incision, and sometimes spontaneously, from the trunk and large branches of a tree, growing in Arabia, and Egypt, especially in Abyssinia. It consists of one-third resin, and two-thirds gum.

N.

NAILS are small spikes or pegs of metal, usually of iron, extensively used in building, and generally in the constructive arts. From the immense quantities of nails made in this country, the manufacture may be deemed one of first-rate importance; for, in the neighbourhood of Birmingham alone, upwards of 60,000 persons, men, women, and children, are occupied in their production; and many of the iron-works in the same district furnish from 100 to 200 tons weekly of "split-rods," of the various sizes and qualities required in the making of the nails (see IRON). The workmen who forge the nails are called "nailors;" women, boys, and girls, are likewise employed in the same kind of work; and it is very common to see a whole family working together. Each individual usually confines himself, or herself, to a certain peculiar class of nails, who, consequently, acquires a great degree of expertness and celerity in their production, not to be equalled by those nailors who have been habituated to forge other kinds.

Under the article FORGE we have given a drawing and a description of a nailor's forge of the most improved description; we have, therefore, only to notice the other tools employed in the art. These are, a small steel anvil, which is inserted in a massive block of cast-iron; and this latter is usually imbedded in slack, so that the steel anvil only is seen. The hammers used are, of course, proportioned in weight to the size of the nail, and the shapes vary considerably, according to the ideas of the workmen; but they are usually the frustrums of cones, the smaller ends of which constitute their faces; the planes of which are not parallel to the handles, but inclined to them. A nailor keeps constantly several rods in the fire, which he takes up in succession as they become hot, so as not to have to wait for a heat. When the shank of the nail has been drawn out to the required form and length, it is nearly cut off the rod by striking it over a fixed chisel, and is then inserted into the heading tool, from which the rod is then

broken off; the nail is then headed in the tool, and turned out of it by turning it upside down, and striking it upon the anvil. Such is the celerity with which these operations are performed, that there are instances of nailors making as many as 3000 nails, of three inches in length, in a day, and continuing to work at this rate for many days in succession. Every such nail requires, at the least, twenty five blows of the hammer to form it, besides two or three blasts of the bellows; nevertheless, the work proceeds at the rate of three or four per minute!

In contemporary publications (the *London* and *British Cyclopædias*) we observe it stated, that the *forged* wrought-iron nails we have been speaking of have been superseded by the introduction of those made by pressure and percussion in machines. But this statement is extremely incorrect, as every person acquainted with this department of art well knows. The fact is, we believe, that the forged nail manufacture has considerably *increased*, notwithstanding there is a very great demand for the cut or pressed nails, which are preferred in some few departments of art, on account of their uniformity, and their square points; and in some others, by reason of their greater cheapness than forged nails. It should be understood that there are three leading distinctions of iron nails, as respects the state of the metal from which they are prepared; namely—

1. *Wrought*, or *forged* iron nails, being worked out entirely by the hammer from rods, or bars.

2. *Cut*, or *pressed* iron nails, which are stamped, or pressed, out of strips of sheet-iron.

3. *Cast* iron nails, in which the metal is melted, and cast in forms of the precise shape of the nails made.

Forged nails are made of three distinct qualities of iron, that is, more or less soft, or tough, according to the purposes for which they are designed. The very best quality is employed for horse-shoe nails, to admit of their being drawn out very fine, and prevent their breaking in the hoof. Wheelwright's nails, which are forcibly nailed against the iron tire, and the clouts, also require the metal to be very tough. In like manner, hurdle-nails require good iron, that the points may clench soundly, and their broad heads not be broken off. The fine or smaller kinds of nails, being much drawn under the hammer, must also be of good iron; and, indeed, all such where great stability is of essential importance. It would, probably, be good policy in the consumer to have all nails made of at least the second best, or medium quality of iron; but the great competition by the manufacturers to render them as cheap as possible, leads to the employment of a very inferior quality of nail rods for making the majority of nails, of which immense quantities are always in demand for the home trade, as well as for exportation to all parts of the world.

Of the wrought, or forged iron nails, there are about 300 sorts, the forms of which are known to the trade by certain specific names, which, for the most part, express the uses to which they are applied; as *hurdle*, *pail*, *deck*, *scupper*, *boat*, &c., but there are others whose applications are so general that they are distinguished by certain technical names, expressive of their form; thus—*rose*, *clasp*, *diamond*, &c., explain the form of their heads, and *flat*, *sharp*, *spear*, &c. their points. The thickness of any specified form is expressed by the terms *fine*, *bastard*, *strong*. The length of some kinds of nails is directly expressed by their lineal measure; but their length is more usually comprehended by the number of pounds or ounces a thousand of them weigh. Thus the simple denomination "7 lb. rose," implies a rose-headed nail with a sharp point, weighing about 7 lbs. to the thousand, and measuring about 1½ inch in length. The rose nails are made from 1½ to 40 lbs. per thousand; in all, about thirty different sizes, and taking the various sizes of other nails (which are not so numerous), we may compute the average number of *sizes* of each sort at 10, which, multiplied by 300, the number of sorts before mentioned, makes 3000 distinctive names to nails, all of which are immediately and precisely understood by persons engaged in the trade. The terms employed by retailers, of fourpenny, sixpenny, tenpenny, &c., are very undefined as respects the kind, as well as the precise size, these varying with the locality wherein they are sold. To enter into

a detailed description of all the varieties we have named would be tedious and uninteresting to the generality of readers; but impressed with the universal utility of more information than we have already given, we shall proceed to a very condensed and systematic view of their peculiarities and uses.

It having been explained how the various sizes and thicknesses are distinguished, it will only be necessary to show the principal distinguishing features without regard to actual dimensions. For convenience, therefore, the several kinds delineated in the following engravings are represented as of one size, and the words printed above and under each, are their proper names.

The first described kind, *rose-sharp*, are very extensively, and almost universally, used for coopering, fencing, and a great variety of coarse purposes, in which hard wood, such as oak and beech, are used. There is, however, a thinner sort, called *fine-rose*, of which prodigious quantities are sent to Canada and other parts, which are used in pine and other soft woods, their broad spreading heads being calculated to hold the work down. The rose, with flat or chisel points, are employed in preference to the sharp, where the wood is in danger of being split by the driving in of the sharp points, which act as wedges, while those with flat points being driven with their edges across the grain, prevent the splitting effect, and hold faster. For these reasons spikes are uniformly made with flat points, from 4 to 12 inches in length, unless ordered to the contrary, for the Brazil market, or other parts of the world, where they may be required for much harder woods than any of our own country.

Of the third sort, *clasp*, there are three distinct thicknesses,—fine, bastard, and strong; and of each numerous sizes. These nails are those commonly used by the London and other house-carpenters, in deal and similar woods; their heads are made projecting downwards, so that when they are driven home flush, their heads stick into the wood and clasp it together, thus checking, to a certain extent, any disposition in the wood to split open; their heads are, in smooth work, driven below the surface, so as afterwards to admit a plane over them.

Of the fourth sort, *clout*, there are, also, three thicknesses of the form of that shown; namely, fine, bastard, and strong; besides numerous sizes. They are much used for nailing iron work, and various substances to wood: they have a flat circular head, round shanks, and sharp points.

There is, however, another kind of clout, extensively used by wheelwrights and smiths, called *counter-clout*, the form of which is delineated in the fifth illustration, which shows that they have counter-sinks under their heads, and chisel points; they are usually made of tough iron, to bear the battering they receive in nailing down the stout iron work for which they are designed: they are made from 1 inch up to 4 inches in length, and of any required thickness.

The sixth figure of the foregoing sketches, is denominated *fine-dog*, in contra-distinction to *strong*, or *weighty-dog*, the difference being merely in their proportionate thickness; these are made from 1½ to 5 inches long, and are used for similar

purposes to the last mentioned, as well as others, where the heads (which are very solid, and slightly countersunk,) are not required to lie flush with the work, their shanks are round drawn, and their points speared, which adapts them for piercing and clenching well.

The seventh nail is called *Kent-hurdle*, probably from having been first used in Kent of that peculiar form: has a broad, thinnish rose-head, a clean-drawn, flat shank, a good spear-point, well adapted for nailing and clenching the oaken bars of hurdles together. There are several kinds of hurdle-nails differing from these, but in points so immaterial as not to require notice in this article. *Gate-nails*, which are nearly allied to them, are similar in form, but are usually made stouter: they are made of various lengths.

The eighth of the foregoing figures, *rose-clench*, is a class used for ship and boat building, of which there are several varieties, and numerous sizes. For the former purpose they are much employed in nailing on the wood sheathing, which is soft, and liable to split, unless bored; and as the nails have no points, the ends being left square, they punch out their own holes, driving a portion of the wood before them, hold very fast, and render boring unnecessary. For the latter reasons clench-nails are now extensively used in the making of packing-cases and boxes, it being found, by experience, that this form holds much firmer when driven in the direction of the grain of the wood, than tapered or pointed nails. The term *clench* is, however, derived from the mode of employing them in boat-building, in which they are clenched, either by battering down the extremity with the hammer, or, preferably, by placing over the extremity a little diamond-shaped plate of metal, as shown in the drawing, and called a *rove*, and riveting the end of the clench-nail down upon it, which draws the planks, &c. of the boat very firmly and durably together. We are surprised that this simple, cheap, and admirable mode of fastening, should be almost wholly confined to boat-building.

Fig. 9 represents the *horse-shoe* nails in general use; formerly the heads were made square, which are now nearly disused, the preference to the counter-sunk being chiefly given on account of their lying flush in the groove made for them, and more securely attaching the shoe to the hoof.

Fig. 10 represents one of a large class of very useful nails, called *brads*; they are made of various thicknesses, according to the strength of the work, and varying in length from ½ to 3 inches.

Deck-spikes do not have rose-heads, as they would leave greater holes in the surface, but either a neat, square, flat head, that beds in flush with the surface, or a clasp or diamond head, as shown in *Fig.* 3. *Scupper-nails* have extremely broad heads for fastening down the lead linings. *Sheathing-nails*, of the ordinary kind, are stout, flat, pointed nails, with clasp heads. There are also peculiarly formed nails for the rudders, the ribs, and various other parts of ships. The nails used in barge-building are chiefly very broad and flat in the shanks, with chisel points. *Pound-nails* are extensively used in Essex, Suffolk, and Norfolk; their form will be understood by reference to the *rose-sharp*, which they resemble in form, but are made stiffer, and with better and more solid heads; they are excellent for coarse, strong work, such as field-fencing, in oak.

Tacks are also a very numerous and useful class of nails; they are technically divided into rose-tacks, Flemish-tacks, and clout-tacks; the Flemish-tacks, however, chiefly obtain; and the heads of these are "Flemished," that is, not raised so much as a rose-head, nor so flat as a clout-head. The sizes of these are from an eighth to three-quarters of an inch in length; or, as they are denominated, from 1 oz. to 16 oz. per thousand. The chief place of manufacture for these, and other very small kinds, is Bromsgrove, in Worcestershire, where it is a common feat of the work-people to forge a thousand (1200) tacks so small as to easily fill the barrel of an ordinary goose-quill, the weight of the whole being about 20 grains.

We could extend our description to numerous other denominations of forged wrought iron nails; but as these, for the most part, differ in merely unessential points from those we have explained, we shall next proceed to the consideration of—

Cast-iron nails. These, from their great brittleness, are applicable to comparatively few purposes, such as garden-walls, the lathing of plasterers, coarse shoes and boots, &c.; and they are desirable for those purposes merely on account of their great cheapness. It should, however, be observed, that cast-iron nails are made of three distinct qualities, two of which are produced by annealing processes subsequent to that of casting. In the state the nails come from the moulds, they are so extremely brittle as to be only applicable to shoes, and those only of the very small short kinds, called sparrow-bills. The cast nails for the use of plasterers, as well as those for garden-walls, and those of similar sizes, undergo a process of annealing to prevent their flying in pieces on being driven by a hammer. The best sort of cast-iron nails are called "malleable cast-iron," from their actually being rendered partially so by a long continued process of annealing; but the metal used for this purpose is very pure, having been deprived of the greater part of its carbon. It is, however, only a few sorts of small nails of this kind, such as tacks, that have stood the test of experience; the annealing process having the effect of not merely destroying the brittle quality, but of rendering the metal nearly as soft as copper, and, consequently, not sufficiently stiff for the purposes designed. All attempts to combine in cast iron nails the properties of adequate stiffness free from brittleness, having failed, the manufacture of *cut* or pressed iron nails by machinery, from sheets of wrought iron, has been resorted to, and it has been attended with considerable success.

Cut or pressed iron nails.—Sheets of rolled iron, of the thickness of the intended nails, are cut into strips or ribands, that are in width equal to the length of the intended nails; being then held horizontally, with a flat side upwards, the ends are pushed in a slide against a regulated stop, under a cutter fixed to a powerful lever, or, as is generally the case, to the lower extremity of a fly-press, which cuts off a portion constituting a brad, or nail. In making brads or sprigs, which have no heads, and are merely wedge-formed pins, the strip of iron is turned upside down, alternately, at every cut, which keeps the inclination of the angle of the cut uniform throughout the length of the strip of iron without any waste. In making brads with half-heads, or bills, the strip of iron is kept with the same side upwards, and the position of the cutter alternately reversed by making a half turn backwards and forwards; thus are formed two *billed-brads* out of one parallelogram. To make this matter understood, we add the annexed illustration:—*a* represents a strip of sheet-iron, which is passed between two guides *b b* against the stop *c*; the line *d d* marks the direction of the edge of the cutter, which may be supposed to have descended and cut off a portion *e*, forming a brad: it will now be seen that if

the strip *a* be turned upside down, and pushed against the stop *c*, the next portion *f* will take the place and position of *e*, and, consequently, be cut off by the next descent of the cutter *d d*; and thus, by repeatedly turning the strip over and back again, and pushing it forward every time with one hand, while the other is occupied in working the lever of a fly-press, the brads are formed with great rapidity. It will be seen, likewise, on reference to those lines marked in the figure, that they represent two brads, with half-heads, or bills, which being placed in that manner, head to point, it is obvious that, by turning the cutter half-way round alternately, they will be cut both alike, out of one parallelogram, as represented. Except for making the larger kind of cut nails, the strength of boys and women is fully competent, who are, consequently, employed in most manufactories, each of them working a distinct press; and headless nails are thus made by each worker with nearly the rapidity and regularity of the ticking of a watch. Ingenuity has, however, devised much more expeditious modes of working, of which the machine we shall next describe is a respectable specimen. It is a recent invention of Messrs. Ledsam and J

Birmingham, to whose enrolled specification of their patent we stand indebted the following information.

Messrs. Ledsam and Jones have given, in their specification, a series of wings, representing two different forms of their machine, together with eral variations in the detail; but it has been our study to comprise all that ential in the following elevation of their apparatus, which, we trust, will comprehended by this explanation:—*a a* in the following engraving,

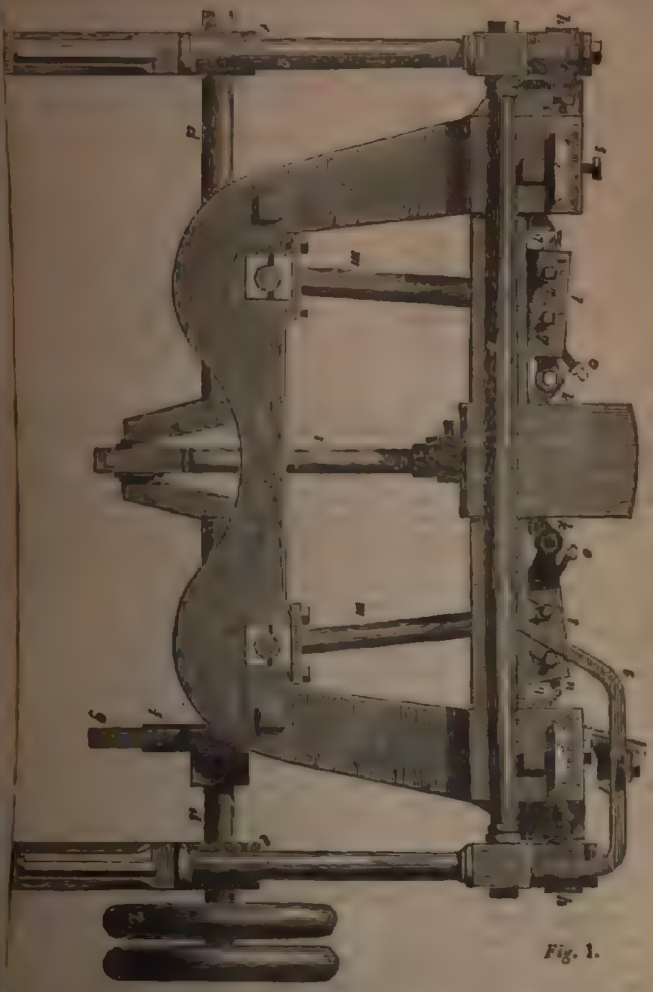
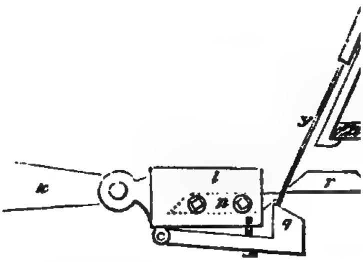


Fig. 1.

nt two (out of four) of the standards to the frame, the other two being nd them, and connected, in a similar way, by horizontal bars, as that . This frame is fixed, and forms the support of a swinging-frame *c c*, and a ontal shaft *d d*, which revolves in bearings at *e e*; *f* is an eccentric on the *d*, regulated by a screw, and acting on a frame *g*, attached to the ng-frame *c*, which latter vibrates upon arms or trunnions *h h*; *i* is a conng rod attached to the crank on the axis *d*, and to the axis of a stout pair

of leaves *k k;* this axis moves vertically in a groove, as shown by dotted l the central cheeks of the swinging-frame; the leaves *k k* are connec hinges to the boxes *l l*, which are supported by the rocking standards *m m* boxes contain the *moving* cutters *n n*, which are kept in their places by (not shown); on the inclined faces of this gauge, the rods, or strips, of the nails or brads are formed, rest; *r r* are fixed cutters in the end ch a swinging-frame, and retained in their places by screws *s s*; *t* a frame at to the fixed frame, and carrying the cross-bar *v*, shown on a larger scale annexed *Fig.* 2; *w* is one of the guide rods hooked on the cross-bar screwed up to a beam above; *x* a perforated weight sliding upon *w*, having its lower end hollowed to receive the ends of the bar, or strip *y*, of which the brads are made. This bar slides down after every cut against the edge of the fixed cutter *r*, and rests upon the surface of the gauge *g*, which determines the breadth of the nail; then the leaf *k* forces forward the box *l*, containing the cutter *n*, which cuts off the iron in a right line with the plane of the under surface of the opposite cutter *r*. *z*, *Fig.* 1, is a band-wheel for communicating motion from the prime move a loose pulley at its side for throwing the machine out of action.

Fig. 2.



The action of the machine is as follows:—By the revolution of the axi eccentric upon it forces the swinging-frame *c* into an *inclined* positio crank on the axis at the same time acting upon the rod *i*, draws the lea into a horizontal position, and thereby forces the movable cutters *n n* f against the fixed cutters *r r*, dividing obliquely the strips of iron placed b them in their progress, the same as if cut by shears; the brads thus form down the inclined surface of the gauge, and are received in a box b The opposite vibration of the swinging-frame makes a second cut, and t both sides of the machine (though represented only on one side) a se rods, or strips of iron, are placed in a line, all of which are cut twice a revolution; thus, supposing eight rods or strips (the number used patentees) are applied to each pair of cutters, 32 brads are cut at revolution of the axis: of course a considerable power being necessar this, that of a steam-engine, or water-wheel, is to be employed in this m in preference to manual labour. The ends of the cutters are only broug view in the figure; these are, however, of greater, and may be of any r length, to cut a given number of brads at a time, as may suit the power engine, and other circumstances. It will now be seen, that, by the pa employing long continuous cutters, and causing them to take an opposite i position at each vibration of the swinging-frame, a number of brads are once, without moving the rods, which drop down to the stop on the ga they are cut. By the former mode described, with the fly-presses, the moves always in the same plane, and the iron is turned round, or in instead. In cutting that species of brads with heads, the patentees cutters with gaps left in their edges, and the cross-bar *v* has slits in it to the rods *y*, and, instead of being fixed, receives an alternating side motio the frame.

For the purpose of *heading* the nails, the shanks made, as already des are usually brought under the operation of a heavy hammer head, which i from its work by a spring pole, like a turner's throw, and is brought dow it by a pedal, worked by a woman, sitting down before a little bench; i of this bench is fixed a pair of clams, which are opened and shut by th

ing of the lever of a screw on the left hand of the operator, who, with her right hand, successively places the shanks between the jaws of the clams, brings the hammer smartly down upon it, which forms the head; and then, by turning the screw with her left hand, the jaws open, and the newly-headed nail drops into a box underneath. The clams are provided with steel dies, impressed with the shape of the under-side of the head and that of the shank, and so much of the length only, as to leave projecting above the top a sufficiency of metal to form the head; the form of the upper surface of the head being determined by a die fixed in the face of the hammer.

There are, however, several manufactories in which the machinery is so constructed as to cut and head the nails by a single operation of the same machine. This mode of manufacturing, we believe, originated in America, where such machinery has been long since in successful use. In 1829 Mr. Edward Hancorne took out a patent for an improvement upon the American mechanism. We have perused the specification of this patent, from which we learn that the invention is "the communication of a foreigner residing abroad;" and that it consists in a machine made of two horizontal frames, the one movable and the other fixed, an axis with a crank, a cam, a fly-wheel, and drum. The bearings of the axis are attached to the lower or fixed frame, and the crank is connected with, and causes the upper or movable frame to traverse in grooved guides on the lower. From an iron rod, of an appropriate size, placed hot into the machine, a piece the size required for a nail is cut off by two cutting edges brought together by the motion of the upper frame, and held between two steels, while the head of the nail is formed by the action of a kind of hammer, whose face is shaped like a die into the form required, and whose stem is acted upon by a kind of cone on the axis. The nail is then to be tapered or pointed by the action of two eccentric steel sectors, whose circular surfaces are placed, at the commencement of the operation, sufficiently apart to receive the thickest portion of the nail; and at the termination of the operation, when they are brought by the motion of the upper frame in a position with the point of contact, is nearly in a line between the centres of motion.

Brass and copper nails are extensively used for shipping, and some other purposes. For nailing on the copper sheathing of ships, nails cast of an alloy of tin and copper are generally used; but great efforts were made by a manufacturer at Bristol, some years ago, to substitute for them nails of pure copper: these, for a time, obtained a preference in the navy yards, as well as the merchants' yards; it having been shown that the bottoms of ships, whose sheathing had been nailed with the rough-headed cast metal nails, were extremely foul, and that to the head of almost every such nail was appended a barnacle, which materially impeded the sailing of the ships. Mr. Guppy (the manufacturer to whom we have alluded) made his nails with a smooth bright head (produced by the polished surface of the hammer,) which, being counter-sunk underneath, were driven down flush with the surface of the copper sheathing. The improvement was evident, and experience showed that ships so sheathed sailed better and returned home from their voyages earlier, and with cleaner bottoms. This triumph, or rather success, was of short duration. Mr. Greenfell, who had for many years supplied the government with copper sheathing and nails, took the hint afforded by the smooth-headed nails, (the admirable construction of which were in other respects the subject of a patent granted to Mr. Guppy,) and had the rough heads of his cast nails made flat, smooth, and bright, on the upper surface, by turning in a simple kind of lathe; and upon repeated trials of these, they were found in no respect inferior to Mr. Guppy's patent, while they were materially cheaper, and they have, in consequence, maintained their ground, to the almost total exclusion of the pure copper nails, for the peculiar purpose mentioned. Pure copper nails are, however, extensively used in ship-building, and sea-going boats, on account of their greater durability than iron, when exposed to the action of salt water. The principal kind in use are *rose-clench*, similar in form to the iron nails of that denomination, already explained and figured. The manner of making these nails is similar to that of the other kinds, and may be readily explained and practised by our brief description. The

copper nail-maker furnishes himself from the copper wire-drawer with *square wire* of the sizes of the intended nails. Suppose, for instance, he has to make some rose-clench, two inches long; he takes the square copper wire of the required thickness of the nail, and, by means of his fixed shears, he cuts the wire into lengths of about 2 inches and $\frac{3}{16}$; the $\frac{3}{16}$ being required to form the head. They are all cut exactly of a length, by the wire being pushed against a stop before it is cut; this stop is fixed to the block, and is adjustable to any required distance from the edge of the shears. The only tools necessary to complete these pieces of wire into nails, are a strong smith's vice, a hammer, and a pair of clams, designed to hold wire of the size. The jaws of these clams open by a spring, and are closed by compressing the jaws of the vice; when so closed they leave a cavity between them, which is occupied by a piece of the copper wire before mentioned, $\frac{3}{16}$ of which project above the upper surface of the clams. The workman then, with one or two blows of his hammer, drives the wire firmly to the bottom of the groove made between the clams (or against a stop placed therein); this has the effect of spreading out the head sufficiently to receive four more blows struck around it in an inclined direction, which produces four facets, meeting at the top, called a rose-head: then, by turning the handle of the vice, the jaws of the clams open, the nail is taken out, and another piece of wire substituted to repeat the heading operation described. It is obvious, that by the same tools, and a different application of the hammer, a flat, a diamond, or other formed head, may be made. To strengthen the heads underneath the upper edges of the clams are slightly countersunk; and in order that a single pair of clams may do for *various lengths* of one sized wire, the groove is made the depth of the longest; and for any nail of a shorter length, a piece of wire is dropped in the groove, as a stop, of such a length as, with the intended nail, to fill the groove entirely. Should the nails thus made be required with flat points, they are flattened by a few blows upon an anvil, in the cold state. Copper in the cold state is worked under the hammer with about the same facility as iron at a cherry-red heat.

NAPHTHA, or Rock Oil, is a yellow or brownish bituminous fluid, of strong penetrating odour, greasy to the touch, and so light as to float on alcohol. By exposure to the air it thickens into the substance called petroleum. There are copious springs of naphtha at Baku, on the shore of the Caspian Sea. There are also at Pitchford, in Shropshire, extensive beds of sandstone, saturated with this fluid, which is separated from the stone by distillation, and is sold under the name of Betton's British oil. The Russians and Persians use naphtha internally, as a cordial. Naphtha burns with a brilliant white flame, and is therefore much used in lamps, both at home and abroad.

NAPIER'S BONES, or Napier's Rods, are certain instruments invented by Lord Napier, for performing some of the fundamental rules of arithmetic, by an easy mechanical process. They may be made of bone, ivory, horn, wood, pasteboard, or any other convenient material. There are five of them, and the face of each is divided into nine equal parts, each being subdivided by a diagonal line into two triangles. In these compartments or squares the numbers of the multiplication table are inserted, the units or right-hand figures being placed in the right-hand triangle, and the tens in the left.

NAPLES YELLOW, is prepared by calcining lead with antimony and potash, in a reverberatory furnace. See Painting.

NATRON. The native carbonate of soda. It is found in vast abundance in the lakes near Alexandria, in Egypt.

NAUTICAL INDICATOR. For finding the latitude, longitude, and variation, invented by James Hunter, member of the Glasgow Philosophical Society. The indicator consists of a stand, supporting a circular plate of polished brass, about 14 inches in diameter, representing the horizon, and marked and numbered accordingly with the proper divisions. This horizon is surmounted by a semicircular plate, as a meridian, set at right angles to the plane of the horizontal plate, properly divided, and furnished with an index attached to a nonius, indicating minutes. This meridian plate is cut out at the centre to allow room for a pivot, or hinge, for other parts of the indicator. On one side of this meridian

are placed two quadrants, and on the other side one, similarly divided as the meridian, and furnished with a similar index and nonius. These quadrants are movable on a pivot or hinge, rising perpendicularly from the centre of the horizontal plate, or agreeing to this centre; they are singly movable on the axis, but capable of being attached at any relative distance, and retained in that situation by a screw, binding together tails attached for that purpose. To the east and west points of the horizontal plate is attached a horary circle, divided into hours, &c. This horary circle represents the daily path of the sun, and it may be furnished with a nonius, as other parts are. This circle is so attached to the horizontal plate, that it can be moved parallel to it to suit the sun's declination; this is effected by the circle being attached to two tangent plates, which, by grooves, slide on the projections from the horizontal plate by means of screws passing through and working in these projections, and carrying the tangent plates, and with them the horary circle, to the degree of the sun's declination. This degree is indicated on a scale of tangent divisions on the tangent plates; and as such tangents are of various lengths, an expanding *vernier* is used to adjust them. Its expansion is effected by friction wheels, and springs working against a proper curve.

NAVE. The central boss, or *hub*, as it is in some places called, of a wheel, through which the axletree passes, and which receives the ends of the spokes in deep mortices made therein. Although the naves made of wood are usually of great solidity, these parts are so subject to strains and concussions as not to be so durable as the mass of material might lead one to suppose. In consequence of this defect, a patent was taken out some years ago for making this part of cast iron, which has been extensively, and, we doubt not, advantageously adopted.

NEEDLES. Well known little instruments, usually made of steel, pointed at one end, and perforated at the other, to receive a thread, for sewing with, &c. The processes of manufacturing needles have been much varied, but the following account combines the most recent improvements.

Steel wire of the size required, after having been annealed, is cut from the coils into lengths of four or five inches; these are gathered up into cylindrical bundles of three or four inches in diameter, over the ends of which are passed two stout iron rings, and more wires in their curved state are forced amongst those in the bundle, until the rings are tightly packed. This bundle is laid upon an iron slab, and over it a bar of iron about two feet long is placed, transversely between the two iron rings; the workman then takes hold of each end of the iron bar, and, pressing it against the bundle of wires, he rolls the latter backwards and forwards over the iron slab until every steel wire in the bundle becomes perfectly straightened. These wires are next pointed upon a grindstone running dry. In this operation, the workman, sitting astride before the stone on a block shaped like a saddle, takes up 20 or 30 wires, laid side by side across a small wooden ruler, covered with soft leather, another similar ruler being laid over the needles to confine them. The workman holds the rulers in his hands, and thus presenting the wires to the grindstone, points them with great dexterity, each one revolving whilst in contact with the stone. After pointing, the wires are cut off the length of the required needles. The next operation is flattening a little the ends that have to receive the eyes. This is effected by a workman taking three or four pieces of wire between his finger and thumb, placing them upon an anvil, and, striking one blow upon each, expands the ends sufficiently to receive the point of the punch, which pierces the eye. This the same person does, before he lays them down, with a small instrument, fixed on the same block as that to which the bandle is fixed. The end of the needle is placed in a small notch in the bed of the instrument, and is put exactly beneath the punch, and a slight stroke of the hammer punches the eye, and at the same time forms the semicircular groove near the eye of the needle, to bury the thread. The notch which receives the needle is made in a piece of steel, which fits into a dove-tailed notch in the bed of the instrument, so that it can be changed for a larger or smaller, correspondent to the size of the needles to be pierced. The workman holds the needles in the same manner

as he did for flatting; and placing them one by one successively in the notch in the bed-piece, pierces them through by a single blow of his hammer in the end of a slider, which recoils to its former position by the reaction of a spring. He now places the next needle under the punch; and when they are all pierced in this manner, he rolls them over by moving his thumb, so as to turn them all half-round, and bring them upwards on the opposite side to that which was pierced; this being done, he repeats the punching on the other side with a view to finish and clear the eye, and to complete the groove which there is in all needles. They are now rounded at the eye end to take off the roughness, which is effected in an instant by applying them to a grindstone.

In making the larger kinds of needles, the grooves are formed, and the eyes pierced, by a stamp and fly-press. A piece of wire of the length of two needles, and pointed at both ends, is placed exactly in the middle, upon a steel die, having the form of the eye groove, &c. projecting from its surface; and over this die is suspended another exactly similar, so that, by means of a blow from the stamp hammer, the two needles between the dies are exactly impressed on both sides with the grooves already mentioned. The piece of pointed wire is then in a similar manner placed under a fly-press, where, by means of two very delicate steel punches falling over corresponding holes in a die, the two eyes are instantly pierced with great precision. These needles are then divided, and the heads corrected with a smooth file. During these operations the needles have become more or less crooked; these are, therefore, placed in files on a smooth metal plate, and with an iron rolled until they are straight.

The next processes are hardening and tempering. To effect these, the needles are placed several thousands together, covered with ashes, in a cast-iron box, and heated in a close furnace to a cherry red, when the box is withdrawn, and its contents dropped into a tub of cold water; they are next taken out of the water, and placed upon an iron plate, kept nearly red hot by means of a fire underneath; here they are carefully distributed about, so as to heat them equally, and until they acquire the blue tinge, when they are immediately removed. Some manufacturers make use of oil or tallow, and other ingredients, instead of water, which substances are supposed by them to improve the process. The needles, thus hardened, are returned to the furnace with the oil upon them, and remain there till the oil inflames, when they are withdrawn, and again cooled in cold water. This second process tempers them; at first they were quite hard, and so brittle as to break with the slightest touch; the tempering renders them tough, yet sufficiently hard to take a good point. When they are hardened in water, according to the former method, it is considered that the proper heat for tempering them can only be determined by long experience and observation; but that the flaming of the oil determines the precise temperature. If the needles be now examined, many of them will be found to have become crooked in the hardening; these are discovered by rolling them over as they lay in rows on a board, and such are selected and made straight by a blow in a notch in a small anvil for the purpose. In some manufactories the needles are next pointed and finished; in others, where the pointing has been already effected, the next process is that called—

Scouring.—In this process the needles are piled in rows many tiers deep, and in several parallel rows, upon a piece of buckram, or stout cloth, which is saturated with oil and fine emery. The needles, after they are deposited, are also sprinkled over with flour of emery and oil, when the whole mass, containing from 10 to 50,000 needles, is tightly rolled up and well bound at both ends. Several of such rolls are operated upon together by a kind of mangle; a stout plank being laid upon the rolls of needles, which is loaded with heavy weights, and made to traverse backwards and forwards for two or three days. During this time several successive wrappers have been completely worn out, which have been replaced by new ones, with fresh charges of oil and emery, and sometimes soft soap. At the end of three days they are thus made very bright [illegible]

[illegible] next operation, called heading and picking, the eyes of all the needles [illegible] in one [illegible], and all the points in another; and all the needles

then eyes or points, are picked. These operations are usually performed ren with a dexterity and rapidity that can only be acquired by practice. dles are placed sideways in a heap, on a table in front of the operator, d puts on the forefinger of its right hand a small cloth cap, or finger-d rolling from the heap from six to twelve needles, it keeps them down refinger of the left hand, whilst it presses the forefinger of the right ntly against the ends of the needles; those which have their points the right hand, stick into the finger-stall; and the child, removing the the left hand, allows the needles sticking into the cloth to be slightly nd then pushes them towards the left side. Those needles which had s on the right hand, do not stick into the finger-stall, and are pushed eap on the right side previous to the repetition of the process; each ut of the finger carrying five or six needles to its proper heap.

nishing operation to the best needles consists in what is termed blue in allusion to the dark polish upon them; this is effected by a revolving a bluish colour, against which the needles, several at a time, are After this they are made up into little packages of from 25 to 100 labelled for sale.

eedles which have, of late years, been so much puffed by the vendors anted not to cut the thread" and to be "gold-eyed" and "silver-e made the same as other needles with these trifling variations;—the he former being produced by dipping them into an ethereal solution of the eyes of the latter have not a particle of silver laid over them, y hue upon them being produced by a peculiar kind of polish. The eyed needles" do, however, possess the merit of being less disposed to read; the eyes of these are made, at first, in the usual way, and are finished by a drilling counter-sink, which improves them materially; eel being softened to enable the drill to cut, they rarely snap or break .

-needles, bodkins, &c.—Some years ago a patent was taken out for needles of this kind, by Mr. William Bell, of Walsall; and as the re of them has ever since been continued with success, we shall close at subject by subjoining that gentleman's brief specification verbatim. thod by which I make needles, bodkins, fish-hooks, knitting-pins, eedles, and sail-needles, is by casting them with steel, or common n, called pig or cast-iron, into moulds, or flasks, made with fine sand; wise, I make stocks or moulds, of iron or steel, or any other compo-able of being made into moulds; on which stocks or moulds I sink, or stamp, impressions of the said articles. Into these I pour my n or steel (I prefer for my purpose sand casting), and prepare my iron s follows:—I melt it in a pot, or crucible, in small quantities about the f twelve pounds (and upwards to twenty pounds), the more con to divest it of its heterogeneous particles, and to purify it from its sulphureous qualities. When the iron has attained a proper heat, I coal-dust, mixed with lime or common salt, which I throw into the lted iron; and, by frequently stirring it with an iron rod, I bring to e of the iron a scoria, which I frequently skim off, and thus bring my a refined state; I then pour it into the mould before described. The ing thus formed, are capable of being softened, hardened, or tempered, l way, by which needles, bodkins, fish-hooks, knitting-pins, netting-nd sail-needles, have, heretofore, been manufactured; therefore, the merit of my invention is in casting them instead of making them in way."

A trellis-like fabric of threads or cords, chiefly used for entrapping , and other animals. The term is likewise applied to a particular manufacture, of a fine open texture, usually applied to the purposes The making of the former description of net is an easy process. The tools merely consist of wooden needles, of different sizes, some round, flat, a pair of round-pointed and flat scissars, and a wheel to wind reads; the strength of the packthread, of which the net is composed

and the size of the meshes, depending upon the particular description of birds or fishes required to be taken. It is necessary, in many cases, to alter the natural colour of the thread; the colour usually used is russet, which is obtained by immersing the thread in a tanner's pit, and letting it lie there until sufficiently tinged. A green colour, which is sometimes desirable, is obtained by chopping some wheat, and boiling it in water, and then soaking the net in the tincture. A yellow colour is obtained by the same process, using the decoction of celandine, which gives a pale straw colour.

Mr. Alexander Buchanan, of Paisley, some years ago invented an ingenious machine for weaving any description of net-work without knots, and likewise to allow the holes or meshes of the net-work to be enlarged or diminished at the pleasure of the operator. The annexed engraving will convey an adequate idea of this machine. A B C D represents a wooden stand, upon which an iron

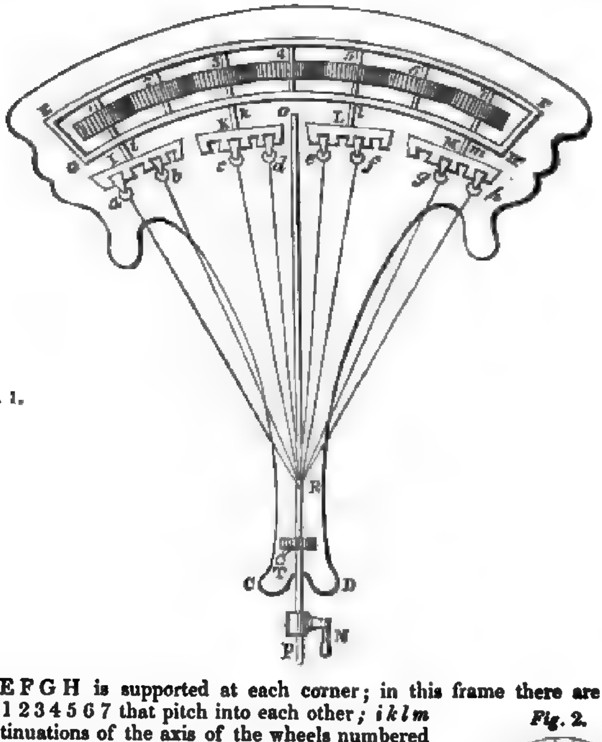
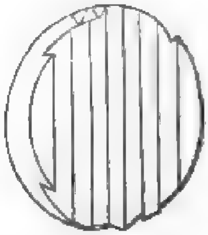


Fig. 1.

frame E F G H is supported at each corner; in this frame there are seven wheels 1 2 3 4 5 6 7 that pitch into each other; *i k l m* are continuations of the axis of the wheels numbered 1 3 5 7; upon the ends of the axis thus continued, circular pieces of wood I K L M are fixed, of which *Fig.* 2 is a representation. The other wheels 2 4 6 are introduced in order that, when the machine is put in motion, those numbered 1 3 5 7 may revolve in the same direction, as it is necessary that the parts of the machine attached to the axis of these should do so. Into each of the circular pieces of wood four grooves are cut, which allow the shuttles *a b c d e f g h* to slide out and in, at the circumferences of the circular woods, but prevent them from coming out when drawn in a direction towards R; the use of the grooves is to allow the shuttles to be moved from one circular wood to another in crossing the threads to form meshes of the net-work. In our figure the circular

Fig. 2.



represented as turned half round, to show the grooves and shuttles in ... pirns, or bobbins, of which one end is considerably thicker than the ... provided with grooves, which, when the bobbin is placed in its proper ... admits a spring, which acts as a counterpart to a weight suspended from ... the threads; each of these springs must be individually so strong ... aggregate strength will prevent the weight from drawing the threads ... ns, and, at the same time, sufficiently weak to allow the threads to ... ly off the pirns when drawn by the operator. Into the centre whee: ... pitches, having the same number of teeth; this wheel, which cannot ... ated in the figure, is fixed to one end of the iron rod O P, at the other ... hich a handle N is attached; by this handle the machine is put in ...

... now given a general description of Mr. Buchanan's machine, we ... the method of using it. The pirns or bobbins having been previously ... thread, or with any other material of which the net-work is to be ..., are placed on the shuttles. The ends of the threads are then col... tied together; after which they are put through a ring that is ... the top of the gudgeon S, and also through a hole T in the sole, or ...nd; a weight is then suspended by the threads, the use of which is ... them from entangling. It must be observed, however, that before ...e is put in motion, the shuttles occupy the proper grooves; this is ... in *Fig.* 1, where the shuttles *a b*, in the circular wood I, occupy the first ... grooves; those of K occupy the second and fourth; those of L the first ..., and those of M the second and fourth. The operator then commences ...e net-work by turning the handle at N; the size of the meshes of the ... increases or diminishes at pleasure, by turning the handle a greater or ...r of times. The wheels are thus made to revolve in the iron frame, the ...ces of wood likewise revolving in consequence of the continuation of the ... of the wheels, by means of which the threads that proceed from the ... each, are twining round each other. The twist made by this move... made fast by the operator, who puts a finger of his left hand between ... threads, and with his right hand inserts horizontally the clearer, which ...iece of wood, shaped like a paper cutter, between each pair of threads, ...oth his hand and the clearer towards R, at which place it is prevented ... farther by a knot. He then removes his hand, leaving the clearer to ... twist tight, and crosses the threads to form the meshes. This is ...y moving the shuttles from one circular wood to another, which ... resembles and effects exactly the same object as the crossing of the ...orking lace; the shuttles of the middle circular woods are changed ...se of the circular wood K, occupying the second and fourth grooves, ... into the second and fourth grooves of the circular wood L, while ... are shifted into the first and third grooves of K; this movement ... a mesh. The operator then turns the handle the same number of ... formerly to twist the other side of the mesh that is already half-... This being done, and the twist made tight by the method just ..., the threads are again crossed, which is effected by moving the ... By the first moving of the shuttles, those of the circular woods K ...ed into the corresponding grooves of L, and *vice versâ*; so that by ...em in the present instance, those which originally occupied L are ... I, and those that originally occupied K into M; this operation com...r two meshes: thus, by twining and crossing the threads, any ... net-work may be wove, the operator drawing more thread off the ...e former quantity is used.

...EL. A white metal, which, when pure, is both ductile and malleable, ...e forged into very thin plates, whose colour is intermediate, between ...ver and tin, and is not altered by the air; it is nearly as hard as iron. ... gravity is 8.279, and, when forged, 8.666. The species of nickel ores ...y with arsenic and a little sulphur, and its oxide. The first is the ...dant, and the one from which nickel is usually extracted. It is known ...ogists by the German name of kupfernickel, or false copper, from its

colour and appearance; it occurs generally massive and disseminated; its colour is copper red, of various shades. By the experiments that have been made, nickel, in its pure state, possesses a magnetic power. The effect of the magnet on it is little inferior to that which it exerts on iron; and the metal itself becomes magnetic by friction with a magnet, or even by beating with a hammer. Magnetic needles have been made of it in France, and have been preferred to those of steel, as resisting better the action of the air. The nickel preserves its magnetic property when alloyed with copper, though it is somewhat diminished; by a small portion of arsenic it is completely destroyed. Nickel is fusible at 150° of Wedgwood, and forms alloy with a number of metals. Nickel is found in Cornwall, and in some other counties of England, in Germany, Sweden, France, Spain, and several parts of Asia. The Chinese employ it in making white copper; and, in conjunction with copper and zinc, they manufacture it into various kinds of children's toys. Nickel gives a certain degree of whiteness to iron; it is used with advantage by some of the Birmingham manufacturers, in combination with that metal; and, by others, in combination with brass. If it were possible to discover an easy method of working nickel, there can be little doubt but it would be found very valuable for surgical instruments, compass needles, and other articles, since it is not, like iron, liable to rust. Oxide of nickel is used for giving colours to enamels and porcelain: in different mixtures it produces brown, red, and grass-green tints.

NITRATES. Compounds of the nitric acid, with various salifiable bases.

NITRE. The usual name given to a combination of the nitric acid with potash. See Acid, Nitric.

NITROGEN. A simple or undecomposed gaseous substance, was first distinguished by Dr. Rutherford, in 1772. It is sometimes called azote, from its inability to support animal life; but it is commonly designated nitrogen, from its being an essential ingredient in nitric acid. It constitutes four-fifths of the volume of the atmosphere, and may therefore be procured by abstracting the oxygen from atmospheric air. It may be conveniently prepared by burning a piece of phosphorus in a jar full of air, inverted over water. The phosphorus, on account of its strong affinity for oxygen, will abstract it from the mixture, and the vessel will become filled with a white cloud, which is the pyrophosphoric acid. In about half an hour this will subside, and the residual gas is nitrogen, contaminated with a little carbonic acid and vapour of phosphorus, both of which may be removed by agitating them with a solution of pure potash. A solution of protosulphate of iron, charged with binoxide of nitrogen, will separate the oxygen from common air in a few minutes. A stick of phosphorus placed in it will accomplish the same in twenty-four hours. Nitrogen gas may also be obtained by exposing a mixture of fresh muscle and nitric acid to a moderate temperature. Effervescence occurs, and a large quantity of nitrogen, mingled with carbonic acid, is evolved, the latter of which may be removed by agitation with lime water. Nitrogen, when pure, is a colourless gas, devoid of either smell or taste; it does not burn, and extinguishes all burning bodies immersed in it; it does not change the blue colour of vegetables; no animal can live in it, yet it exerts no injurious influence on the lungs or other parts of the animal system, the privation of oxygen being the sole cause of death. Water, when deprived of air by boiling, takes up about one and a half per cent of it. Its specific gravity is .9722; and therefore 100 cubic inches, at a mean temperature and pressure, will weigh 30.15 grains. In the combination of nitrogen with oxygen in the atmosphere, it seems merely to moderate or dilute the oxygen, so as to render its action less energetic. Considerable doubts have existed as to its simple nature, in consequence of experiments made with the galvanic battery. When ammonia (which is a compound of nitrogen and hydrogen) is submitted, in conjunction with mercury, to the action of galvanism, an amalgam is formed, which is considered to arise from some metallic base in the hydrogen or nitrogen; but as the idea of a metallic base to hydrogen seems precluded by reason of its extreme lightness, it has seen inferred that it must form a constituent of the nitrogen. This supposition, however, seems incapable

of proof, as the constituents of the amalgam separate, and are resolved into ammonia, hydrogen, and mercury, as soon as the galvanic influence is withdrawn. Nitrogen unites with several substances in different proportions, forming a variety of compounds, distinguished by striking peculiarities. With oxygen are formed the nitrous and nitric oxide, and the hypo-nitrous, nitrous, and nitric acid. With chlorine and iodine it forms the chloride and iodide of nitrogen, and with hydrogen it forms ammonia. Our limits will permit us to give but a brief account of these. The nitrous oxide, or protoxide of nitrogen, was discovered by Dr. Priestley in 1772, who called it dephlogisticated nitrous air. The best mode of procuring it is by means of nitrate of ammonia. When this salt is exposed to a temperature of 400° or 500° Fahr. it liquefies, and bubbles of gas begin to escape, and in a short time a brisk effervescence ensues, which continues till all the salt disappears. The nitrate of ammonia should be contained in a glass retort, and the heat of a lamp applied, so as to maintain a moderately rapid evolution of gas. In accurate experiments the gas must be received over mercury; but for ordinary purposes it may be received over water. It has a sweet taste, and a faint, agreeable odour, and is absorbed by its own volume of recently-boiled water. Most substances burn in it with far greater energy than in the atmosphere; but the most remarkable of its properties is its effect when respired. A few deep inspirations are followed by the most agreeable feelings of excitement, similar to the early stages of intoxication. This is shewn by a strong propensity to laughter, by a rapid flow of vivid ideas, and an unusual disposition to muscular exertion. These feelings soon, however, subside, and the person recovers his ordinary state without experiencing that languor which is the usual result of excitement by spirituous liquors. It varies somewhat in its effects on different individuals, and sometimes produces disagreeable symptoms. The specific gravity of this gas is 1.5277; and 100 cubic inches weigh 47.377 grains The binoxide of nitrogen, or nitric oxide, is best obtained by the action of nitric acid of specific gravity 1.2 on metallic copper. Brisk effervescence ensues, and the gas may be collected over water or mercury. The nitric oxide is a colourless gas; but when mixed with oxygen or atmospheric air, dense suffocating, orange-coloured vapour of nitrous acid is produced. Few inflammable substances burn in it; charcoal and phosphorous, however, when in vivid combustion, burn in it with increased brilliancy. It is sparingly absorbed by water, does not redden vegetable blues, and is quite irrespirable. 100 cubic inches weigh 32.3 grains, and its specific gravity is 1.0416. The hypo-nitrous acid has not hitherto been obtained in a free state, but combined with potash. Pure nitrous acid is formed by the mixture of binoxide of nitrogen with oxygen gas, out of contact with either water or mercury. When condensed in water, it forms the liquid nitrous acid.

NORIA. See Hydraulic Machines.

NUTGALLS. Excrescences formed on the leaves of the oak by the puncture of an insect, which deposits an egg upon them. The best galls of commerce are those imported from Aleppo; they are chiefly used by dyers, calico printers, and ink makers, and are peculiarly valuable on account of their richness in tannin and the gallic acid.

NUTMEG. The kernel of a large fruit, not unlike the produce of the miristica. The nutmeg is separated from its investient coat, the mace, before it appears in commerce.

O.

OAKUM. The substance into which old ropes are reduced when they are untwisted, loosened, and drawn asunder. It is used chiefly for caulking the seams of ships.

OAR. A long piece of timber, flat at one end, and round or square at the other, used to propel a vessel through the water. The flat part, which is

dipped in the water, is called the blade; and that which is within the board is termed the loom, whose extremity, being small enough to be grasped by the rowers, is called the handle. To push the vessel forwards by this instrument, the rowers turn their backs forwards, and dipping the blade of the oar in the water, pull the handle forward, so that the blade at the same time may move aft in the water. But since the blade cannot be so moved without striking the water, this impulsion is the same as if the water were to strike the blade from the stern towards the head; the vessel is therefore necessarily moved according to the direction. Hence it follows that she will advance with the greater rapidity, by as much as the oar strikes the water more forcibly; consequently, an oar acts upon the side of a boat or vessel like a lever of the second class, whose fulcrum is the station upon which the oar rests on the boat's gunwale. In large vessels this station is usually called the row-port, but in lighters and boats, the row-lock. Oars for ships are generally cut out of fir-timber; those for barges, out of Dantzic or New England rafters; and those for boats, either out of English ash or Norway fir rafters. See BOAT.

OBSERVATORY. A building purposely constructed for viewing the heavenly bodies, and furnished with suitable instruments and conveniences for facilitating the operations.

OCHRE, (*red*,) is an iron ore of blood-red colour, which is sometimes found in powder, and occasionally in a hardened state. It has an earthy texture, and sometimes stains the fingers when handled. The principal use of red chalk is for drawing. For the latter purpose, it should be free from grit, and not too hard. In order to free it from grit, and render it better for use, it is sometimes pounded, washed, mixed with gum, and cast into moulds of convenient shape and size. Under the name of reddle, this substance is much used for the marking of sheep, and when mixed with oil, for the painting of pales, gates, and the wood-work of out-buildings.

ODOMETER. An instrument for measuring the distance travelled over by a post-chaise or other carriage; it is attached to the wheel, and shows, by means of an index and dial-plate, the distance gone over.

OIL. The distinctive characters of oil are unctuosity and inflammability, insolubility in water, and fluidity at moderate temperatures. Oils are distinguished into *fixed*, or *fat* oils, which do not rise in distillation, at the temperature of boiling water; and *volatile*, or *essential* oils, which do rise at that temperature with water, or under 320° by themselves. The latter having been treated of under the word ESSENTIAL, in the preceding part of this work, we shall here confine our attention to the former class chiefly.

Fixed oils are generally contained in the seeds and fruits of those vegetables of which they are the products, and are formed principally at the period of maturity. They are extracted by pressure, sometimes with, and sometimes without, the aid of heat. They are usually impregnated with the mucilaginous or extractive matter of the vegetable, whence they acquire colour, odour, and taste; and if heat has been employed to favour their extraction, they acquire acrimonious qualities, and undergo a change in some of their chemical properties. The purest oils are those expressed from the fruit of the olive, or the seeds of the almond; others less pure are extracted from linseed, hemp-seed, and numerous other seeds of plants. Fixed oils are usually fluid, but of a thick consistence, and they congeal at moderate temperatures; some are even naturally concrete. When fluid, they are transparent, colourless, or of a yellowish or greenish tinge, inodorous, and insipid; they are lighter than water. The following table exhibits the specific gravities of the principal sorts of commerce; water being 1.000:—

Cacao	0.892	Almond	0.939
Rape seed	0.913	Linseed	0.939
Olives	0.913	Poppy	0.939
Ben	0.917	Hazel-nut	0.941
Beech-nut	0.923	Palm	0.968
Walnut	0.932		

Fixed oils are incapable of combining with water; and are very sparingly soluble in alcohol, in the cold, with the exception of castor, which is abundantly dissolved by rectified alcohol, and of linseed oil, which is dissolved, though more sparingly; boiling oil dissolves it, and also the others in sensible quality.

Expressed oils cannot be volatilized by heat, without a change of their properties. At temperatures below 600° of Fahr. they remain fixed, if the heat has not been for a long time continued. At the temperature mentioned, they are converted into vapour, but the oil condensed therefrom is altered in its properties; it has lost its mildness, and has become more limpid and volatile, a portion of carbon having been deposited. Transmitted through an ignited tube, oil is converted into carbonic acid, and carburetted hydrogen, with a small portion of acid liquor, and a residium of charcoal. Exposed to a warm atmosphere, expressed oils gradually acquire a sharp taste and smell, and become thick. This change, termed rancidity, is owing to absorption of oxygen. Drying oils, as those expressed with the aid of heat are named, do not become rancid, but by absorbing oxygen, are partially converted into a resinous kind of matter. At the temperature of ignition, at which it is converted into vapour, oil burns in atmospheric air, a large quantity of light and heat being extricated by its combustion. When the access of the air to the vapour of the oil is insufficient, it burns with a black smoke, and a quantity of carbonaceous matter which has escaped the combustion is deposited. Hence the utility of a slender wick, which draws up the oil by capillary attraction, and when kindled, produces sufficient heat to convert it into vapour. In a hollow cylindrical wick, like that in the Argand lamp, through which an internal circulation of air is established, the supply of air is more abundant, and the whole of the oil is consumed; the illumination therefore is greater, though there is some diminution of it in consequence of the light from the internal surface having to pass through the flame. Expressed oils combine with the alkalies, and form soap, which see. Expressed oils dissolve phosphorus by the aid of heat, forming a liquid, which becomes luminous when exposed to the air. They combine with a number of the metallic oxides, and acquire thereby a drying property. Boiled with oxide of lead, expressed oil forms a compound of firm consistency, constituting the "common plaster" of the apothecaries. Expressed oils form the basis of paints (see Painting), and are hence called oil-colours, (see also, Oil-colour Cakes, annexed to this article.) Expressed oils, combined with resins and turpentine, form varnishes; (see Varnish.) Combined with lamp-black, they form printing-ink, (see Ink.) For most of these uses, however, the drying-oils are employed. There are two distinct processes of obtaining oil by pressure; one cold, the other warm; the cold-drawn oil being preferable for one purpose, and the warm for another. In the former, the substances are submitted to pressure, without increasing their natural temperature; in the latter, heat is artificially applied, generally through the medium of steam or air. The application of heat to seeds and most oleaginous matters, causes a great quantity of the oil to flow out, without pressure; and heat softens them so much, that less mechanical force becomes necessary to expel the remainder. It is therefore an indispensable point of economy to make use of heat whenever the application of it does not deteriorate the quality of the oil; for more oil is thus obtained with less labour. In the large manufactories, linseed and rape-seed are the chief vegetable substances from which oil is obtained in this country; heat is usually employed before pressure, and the separate products of oil in the different stages of manufacture are preserved, as distinct qualities. The ordinary "mill" for this purpose consists usually of an extensive range of machinery, and is usually distinguished by the denomination of the Dutch Mill, as the industrious people of Holland were the inventors, or chief improvers of it. In these, the seeds are put into bags, and covered with envelopes, consisting of hair-cloth, and sheep-skin sewn together; in this state, they are subjected to pressure by the force of wedges, that are continually being struck by perpendicular stampers. These stampers are raised by cams fixed to a revolving axis, (worked by a steam-engine, or other adequate power,) and fall from the height they are thus raised upon the wedges. The oil thus expressed, runs off, and is conducted to a cistern,

and the seed in the bag is reduced to a very hard solid cake, which is sold for the feeding of cattle, as it retains a considerable portion of farinaceous and other nutritive matter. Of late years the elastic force of steam has been introduced to give the necessary pressure, and the patented improvements by Mr. John Hall, jun. (of Dartford), which we have now to describe, consist in the peculiar method by which this power is applied. *a a* (*Fig.* 1) are two elliptical iron cams, firmly fixed on the horizontal shafts of two cog wheels, which gear into one another; B B *b b*, are massive iron plates, between which the seed bags *c c*, in their envelopes, are placed; *d* is the steam cylinder; *e* the piston to the same, which, when raised by the force of the steam from underneath, elevates the beam *f*, and the connecting rods *g g*; these being attached to the levers *h h*, turn the cams so as to press against the plates B B; which pressure is continued until the cams arrive with their longest diameters in an horizontal direction, as shewn by *Fig.* 2. By these means the oil is squeezed out, and received into a proper receptacle underneath. On the other side of the steam cylinder, another aparatus, similar in all respects to that shewn, is fixed, and moved by the same power; but in these the longest diameters of the cams are placed in a reverse direction, or at right angles with those in the engraving; so that when the utmost pressure is excited on one side of the cylinder by the ascent or descent of the piston, no pressure whatever is given on the other, and the bags may be removed to be emptied, and replenished with a fresh quantity of seed. The employment of elliptical cams is altered with a very great convenience, which we ought not to omit noticing. The two innermost plates B B are connected together by means of straps, as shewn at *i i* (*Fig.* 2) stretched out while the cams are exerting their pressure; when that pressure is relieved by the cams being turned into the position of these in *Fig.* 1, the connecting straps *i i* are raised, and the two plates B B are drawn towards one another; the bags are then perfectly free to be removed by the workman, to be filled again and replaced; and so on alternately, on opposite sides, at every ascent or descent of the piston.

Fig. 1.

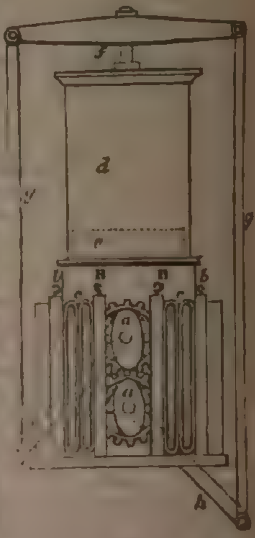


Fig. 2.

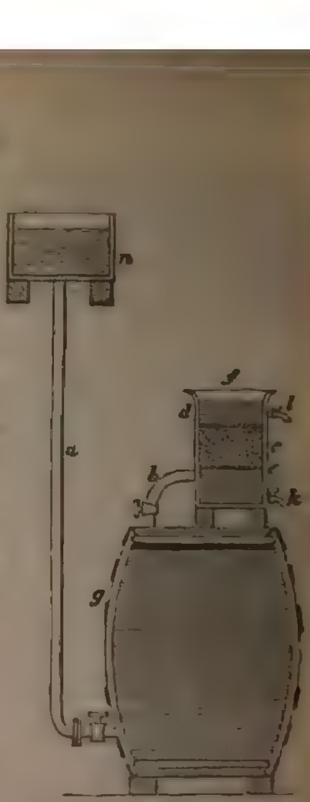
The steam pressure upon the piston, employed by the patentee, is from forty to fifty pounds upon the inch, nearly the whole of which, owing to the simplicity of the apparatus, is transferred to the end of the cams, where the power is increased according to the ratio of their surfaces, compared to that of the piston. A steam apparatus is constructed near to each pair of cams, for the convenience of heating the seeds, with means for discharging the cake and refilling the bags.

In the year 1828, the Society of Arts presented Mr. Cogan with their silver medal, for the communication of a process for purifying rape and linseed oils. Mr. Cogan's process, though resembling M. Thenard's in the first part of it, is completed by the judicious introduction of steam; by means of which the oil appears to be almost entirely freed from acid, and the black feculent dregs subside in the course of twelve hours, leaving the upper portion of the oil quite clear, and greatly improved in colour, and in those qualities for which it is valued by the painter. The quantity of oil that he operates upon at once is about 100 gallons. For this, three quarts, that is about ten pounds, of sulphuric acid, oil of vitriol, is required. The acid is to be diluted with an equal bulk of

water. The oil being put into a copper pan, of the shape of a boiler, two quarts of the dilute acid are to be added; the whole is then to be stirred up very carefully for an hour or more, with a wooden scoop, till the acid is become completely incorporated with the oil, and the colour of this last has become much deeper than at first. A second similar quantity of acid is to be added, and mixed with the oil, the same as the first was; and after this the remaining third part of acid is to be added. The stirring of the oil is to continue incessantly about six hours in the whole, at the end of which time the colour of the mixture will be almost that of tar. It is then to be allowed to stand quiet for a night, and in the morning is to be transferred to the boiler; this is of copper, and has a steam pipe entering it at the bottom, and then dividing into three or four branches, each of which terminates in a perforated plate. The steam thus thrown in, passes in a very divided state into the oil, penetrates into every part of it, and heats it to the temperature of boiling water. The steaming process is to be continued for about six or seven hours, at the end of which time it is to be transferred to a cooler, of the form of an inverted cone, terminating in a short pipe, commanded by a stop-cock, and also having a stop-cock inserted in its side, a few inches from the bottom. After remaining a night in the cooler, the oil is fit to be withdrawn; for this purpose, the cock at bottom is opened, and the black watery acid liquor flows out. As soon as the oil begins to come, the cock is closed, and that in the side of the cooler is opened. From this the oil runs quite clear and limpid; the whole of that which is still turbid remaining below the upper cock. The purified oil being drawn off, that which is turbid is let out into a reservoir, where it either remains to clarify by subsidence, or is mixed with the next portion of raw oil.

The following is the patented process adopted by Mr. M. Wilks, seed crusher of Dartford, for purifying the oil from linseed, as well as other seeds, by expression. Into 236 gallons of the oil, six pounds of oil of vitriol is to be poured, and be well mixed by agitation or stirring about for three hours. Six pounds of fuller's earth is next to be mixed up and thoroughly incorporated with fourteen pounds of hot lime and thrown into the vessel containing the oil and vitriol, when the whole is to be kept in agitation for about three hours more. The foregoing mixture is next to be turned into a boiler containing a quantity of water equal to that of the oil, and the whole is then to be boiled for another three hours, during which time the liquid is to be continually agitated by stirring. The fire may now be extinguished, and when the materials have become cool, the water may be drawn off, and the oil will be found clarified, which will become brighter and more fit for use after standing some time.

Mr. Robinson, of Edinburgh, having witnessed the difficulties and waste which take place in filtering and clearing oil from its dregs; in which operations, as it is usually conducted, a great deal of the advantage which is gained by repose and subsidence, is again lost in drawing off the oil to pass it through the filter, it appeared to him that by introducing water through a regulated aperture, and from a height sufficient to give the requisite hydrostatic pressure into the bottom of the butt of oil, and making a communication from the top of a butt, to a filter acting by ascension, all the advantages arising from refuse and subsidence would be retained, and by adapting the nature of the filter to the quality of the oil, the contents of any butt might be easily and quickly separated into three or four portions of different degrees of value. Mr. Robinson [illegible] by suggesting the mechanical arrangement, represented by the section of the apparatus in p. 200. *n* is a cistern of water which communicates by the pipe *a* with the bottom of the butt of oil *g*. *f* is the filter raised on feet, and standing on the heading of the butt, with which it communicates by the pipe *b*. *e* is a perforated plate above the lower chamber of the filter, and *k* is the discharging cock; *c* is the middle chamber filled with charcoal, or any other suitable substance. The partition between this and the upper chamber *d*, is a perforated plate, and *l* is the discharging pipe of that chamber. The butt containing the oil being connected with the apparatus already described, the cock of the pipe *a* is to be turned, which will allow the water to flow into the butt. At the same time the cock of the pipe *b* being opened, the upper part of the oil,



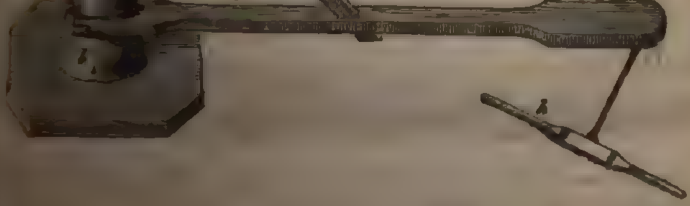
and therefore the purest, first flows into, and fills the lower chamber of the filter, and is followed by the less pure portions, according to their respective specific gravity; but as the pipe enters this chamber at the top, those impurities that are considerably heavier than the oil will subside to the bottom, and are from time to time to be discharged through the cock. The rest of the oil rises through the perforated plate, is separated from the lighter impurities by the charcoal or sand in the middle chamber, and then passes through the upper plate into the top chamber, whence it flows through the cock *l*. The two perforated plates must rest on rings or projecting ledges, that the charcoal may be renewed and the lower plate may be taken out occasionally, and cleared of the dregs which otherwise would stop its holes.

Under the words Elaine, and Fat, we have noticed the fine fluid oil that has received the former denomination, and which has been employed for lubricating delicate horological machinery. In this place, we have to describe an improved mode of obtaining it from olive oil by Mr. Henry Wilkinson, of Pall Mall, and which is considered to be peculiarly valuable for lubricating the pivots and other rubbing surfaces of chronometers. The best olive oil in its recent state, possesses that peculiar bland flavour which fits it for the table, and which appears to arise principally from the quantity of mucilage and water, either held in solution, or mechanically mixed with it. By keeping one or two years in jars, a considerable portion of the mucilage and water subsides, which renders such oil not only cheaper, but better qualified for yielding a greater proportion of *pure* oil than that which is recently expressed from the fruit. Two or three gallons skimmed from the surface of a large jar that has remained at rest for twelve months or upwards, is preferable to any succeeding portion from the same jar, and may be considered the cream of the oil. Having procured good oil in the first instance, put about one gallon into a cast-iron vessel capable of holding two gallons; place it over a slow clear fire, keeping a thermometer suspended in it; and when the temperature rises to 220°, check the heat, never allowing it to exceed 230°, nor descend below 212°, for one hour, by which time the whole of the water and acetic acid will be evaporated; the oil is then exposed to a temperature of 30° to 36° for two or three days, (consequently winter is preferable for the preparation, as avoiding the trouble and expense of producing artificial cold); by this operation a considerable portion is congealed; and while in this state, pour the whole on a muslin filter, to allow the fluid portion to run through; the solid, when dissolved, may be used for common purposes. Lastly, the fluid portion must be filtered once or more, through newly prepared animal charcoal, grossly powdered, or rather broken, and placed on bibulous paper in a wire frame within a funnel; by which operation, rancidity (if any be present) is entirely removed, and the oil is rendered perfectly bright and colourless.

Under the article Candle, the reader will find accounts of several patented processes for obtaining the *elaine*, or pure oily principle, from the cocoa-nut, palm, and other concrete vegetable oils, so that we need not repeat them under the present head; but the extremely rude and ineffective machinery employed by the natives for expressing oils, in those countries from whence we derive our

supplies, is worthy of the attention of the British reader, as exhibiting in a strong light the advantages that might result from the introduction of improved machinery in those parts. Dr. Davy informs us that the means used by the Singalese for this purpose, consists merely of a few upright poles stuck in the ground, supporting two parallel horizontal bars between them; between these, the bags containing the seeds are put, in the manner represented in the subjoined sketch, pressure being given to the bags by means of a perpendicular

lever which forces the horizontal bars together. The native oil press employed at Madras, and other parts of the East, has somewhat more the character of a machine. The machine is large and substantial, and a great amount of animal force is wanted in operating by it. The annexed drawing is taken from a model recently brought from India and deposited in the museum of the Asiatic Society.

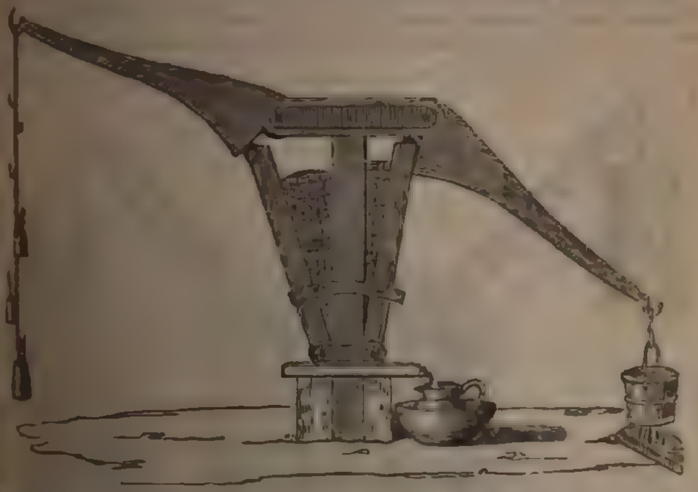


a represents a mortar about six feet high, usually formed out of a block of granite, but sometimes of wood; in both cases, there is as much of the substance sunk into the ground as remains above it; *c* is a pestle, the upper extremity of which fits loosely in the piece of timber *d*; at *e* is another piece of timber, attached by

cords to *d*, (by passing round the projecting pins shown) with its lowe
tised and bolted to the horizontal lever *g*; one of the ends of this lever
as at *f*, so as to pass into and around a groove made in the mortar;
part *b* of the mortar, enlarged in its dimensions, serves as a rest for th
and to give steadiness to the apparatus. To put this machine into o
man sits upon the end *g* of the horizontal lever, which by the conne
e and *d*, cause the pestle *e* to press hard against the sides of the mo
circular motion is given to the pestle by attaching a pair of oxen to
h, who draw it round. An oil press on the same principle as this, is
by Dr. Buchanan, as being used by the oil makers of Bangalore for
various kinds of oil. These mills receive a quantity of seed, equal
2½ of our Winchester bushels, to which in the course of grindi
2½ quarts of water are gradually added. The grinding contin
hours, when the farinaceous parts of the seed and the water fo
and this having been removed, the oil (about 5½ gallons in quantity
clean and pure in the bottom of the mortar, from whence it is taken
The mill requires the labour of two men and four oxen, and grin
day, thus making, in the whole, but 11 gallons per day; and if this
so large a machine and so great a power can perform, how miserably
must be the Singalese machine we first described. The writer of
was so forcibly impressed with this defective mode of oil-pressing s
ago, as to lead him to devise some powerful machine, in which the co
should be few, of the simplest kind, and that should be easily m
roughest rural workman at a trifling expense, and be, as much as po
acting. The approbation which the principle of these presses hav
from professional engineers, and the practical experience which th
has had of their utility and convenience in a nearly similar applicati
him to give a brief description of them in this place; in the perusa
the reader will bear in mind that they are especially designed fo

manufacture of oil on the spot where the seeds grow. This machi
simply of three pieces of wood; an upright piece is fixed firmly in th
(a tree would answer the purpose well,) near the lower end of which
at the upper extremity, are projecting pieces, the upper one forming
the long horizontal lever, and the lower one the joint of the short ve
to strengthen these joints a strap of iron is laid over them, and
upright post, and iron bolts are passed through each to form th

fulcrum, to each lever; the band near the middle merely serves as a stay to support the vertical lever when it is thrown back. It will be observed that a roller is fixed to the upper extremity of the vertical lever, which, running upon the inclined plane of the horizontal lever, renders the friction of these parts, when in contact, very trifling: but what we consider as the most important result of this peculiar combination of two levers (which are both of the second class) is, that the effect of the power employed is but little at the commencement of the operation, but that the pressure is continually increasing during the operation, and becomes prodigiously great towards the close of it, which is owing to the pressure on the vertical lever constantly accumulating (of itself without attention) as it approaches the fulcrum of the horizontal lever. Now this is precisely what is wanting in oil or wine-pressing: if a great pressure be given at the first, the bags burst and the liquid is lost. It is obvious, from the sketch, that the Indian who is seated in a swing, suspended to the lever, is the acting force; and as this force is obtained not only without labour, but by rest to the individual, there cannot be an easier mode of producing a mechanical effect, especially as some attendance to the process going forward is necessary. A shoemaker, or a tailor, might, indeed, carry on the business of their crafts, and, at the same time, work an oil or a wine-press upon the same principle. The design having been made with reference to the conical bags employed in India for the purpose, will account for this peculiarity in the drawing, as well as the subjoined modification of the machine, which is merely an extension of the principle to the forming of a double press. By this arrangement double

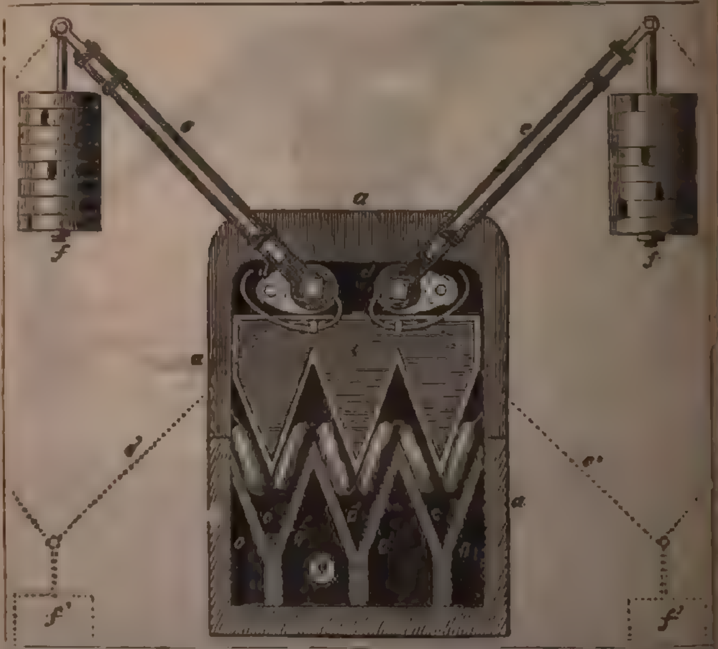


the effect is produced at about half the additional cost of one press; and if both presses were worked together (which might always be the case), instead of the central post being fixed in the ground, it might be put on a movable stand, as the weight of force of one press would counterbalance that of the other. This sketch likewise shows two convenient modes of working the press with very little attention; to one of the horizontal levers a rope is suspended, having loops at convenient distances, upon which such weights may be hung as may be found necessary to give the required pressure; to the other is suspended a bucket (the capacity of which would be regulated by the circumstances), to take advantage of a descending current of water (if the locality admits of it), or of a reservoir, or supply pipe, that might be raised to a proper elevation for filling it; when the operation is completed, as represented on one side of the

press, the bucket falling against a tail-piece fixed upright in a channel or gutter, opens a valve, lets all the water out of the bucket, and relieves the press from the force of its weight. Thus in a situation where water is plentiful, a number of large presses, charged with the necessary materials for obtaining oil, or wine juice, might be filled over-night; the next morning the buckets would be found discharged of their water, and the previously empty recipients be found filled with oil without any attendance whatever. It is, perhaps, deserving of notice, that the self-acting property of these presses adapts them for situations where advantage could be taken of the ebbing and flowing of the tide; the rising of the water would thus fill the buckets, and, upon its falling, leave them suspended with their loads to do the work of the press; the return of the tide would take off the pressure for the renewal of it upon its descent; and thus, every twelve hours, the presses might be worked with almost unlimited power and without any attendance to the moving force.

The most powerful and the most convenient machine for expressing oils, is, unquestionably, the hydrostatic press invented by the late Mr. Bramah. A press of this kind was sent out to Ceylon, by government, in the year 1814, which was made by Mr. Bramah expressly for the purpose of expressing oil from the cocoa-nut kernel; a very full description of all the important details of which is given in the thirty-fourth volume of the *Transactions of the Society of Arts*. But although the hydrostatic press is the most economical machine that the capitalist can employ, its expense is unsuited to the means of the small, or middle, manufacturers, to whom a press of some kind is indispensable; accordingly, the following one has been designed to meet their wants.

The annexed figure gives a front view of the machine, excepting that the front plate which encloses the lower part of the machine, and the bearings of the axes of the cams are removed to show better the construction. *a a a* is a



strong frame of cast-iron (it may be of wood strongly bolted together); the size may be as circumstances may require; but a convenient size would be 3 feet

h, two feet wide, and 1 foot from front to back. *b* is the pressing-head, of [illegible] wood, formed into three wedge-shaped teeth, and made so as to fit into a [illegible] *c c c*, of a corresponding figure; *d d* are two cams, firmly attached to two [illegible]pending levers *e e*, which are loading at their extremities by suspending [illegible] to any required number of flat circular weights: to each of the cams a strong hook, bent to the figure of the former, is fixed; and these hooks passing through [illegible]es or staples, in the head of the press, lift it up when the pressure is taken [off], allow it to descend without obstruction, and keep them always connected. [illegible] *g* is an aperture for conveying, by means of a pipe, hot air, or steam, into [the] chambers *o o o*, which have lateral openings one into the other; the angular [illegible] of this chamber adapts it for collecting the heat, air, or vapour, whence it [passes] through the interposing iron plates into the bags under pressure. The [bags] being placed between the wedges as shown, the pressure is given by load[ing] the levers (which may be drawn out to any length required), which gra[du]ally causes them both to descend to the position shown by the dotted lines *e' e'* [and] *f' f'*; at which time the cams have turned a quarter round, so as to attain a [vertic]al position when their utmost effect is produced. The bags between the [w]edges are thus compressed by a great force, and their contents reduced to hard [illegible] cakes, while the expressed oil runs off in the angular gutters at the bottom, [an]d is conducted out of the machine, by a pipe, into a proper recipient.

The operation being completed, the pressure is taken off by removing the [we]ights (already close to the ground), and throwing up the levers which lift the [hea]d of the press, the chief labour of which may be obviated by a counter[b]alance weight. The oil cakes being taken out of the press, other bags, pre[vio]usly prepared, are put in their place, and the operation renewed simply by [rai]sing the levers, leaving them to do their work unassisted, and accumulate in [pow]er as they move through their assigned space. It should here be observed, [th]at owing to an oversight in the drawing, the levers are not shown as fixed in [th]e best position for commencing the operation. They should be placed slightly [incl]ined from the vertical position; the power would then be considerably [lesse]ned at the beginning, and vastly increased towards the end. The extre[mit]ies of the cams are furnished with strong anti-friction rollers, which come [into] action at the end of the process.

The action and power of this press may be described and estimated thus: [th]e levers *e e* being *fixed* to the cams act with them as entire pieces, hence [mu]st be regarded as two bent levers, in which the points of pressure are con[stant]ly changing their position. Now supposing 5 cwt. appended to each [illegible], and each lever when drawn out to be ten feet long, and the pressure [to] be given at one inch from the fulcrum, this would give a power of 120 [illegible], or 60 tons upon the head of the press. The head of the press, it will be [obse]rved, moves through a space, the treble of that which is between the [opp]osite planes of the wedge-formed teeth, consequently, the power is here [incre]ased threefold, or raised to 180 tons; then, by applying similar levers and [weig]hts to the opposite ends of the axes of the cams, we have the force of 360 [tons] upon the goods in this little self-acting lever press. The friction in such a [mach]ine is undoubtedly considerable, but as any additional force within the [illegible] of the strength of the structure may obviously be added, and the point [o]f pressure be brought nearer to the fulcrum than the distance mentioned, at [th]e close of the operation, any required power may be obtained at the period [wh]en it is wanted, to squeeze the cakes thoroughly dry. The oil-maker will do [we]ll to consider, that the force transmitted to the screw presses as well as by the [illegible] is *intermissive*, and not a *constant self-accumulating force*, as exerted [b]y the lever presses we have just described.

Fish Oil.—In the Greenland fisheries, the blubber produced from whales is [cut] into small pieces and packed in casks, and when it arrives in England, it is [in a] putrid state. It is started into a large receiver, containing about twenty [tons]. There is a semicircular wire grating in the side of the back, close to the [bott]om, through which the fluid parts drain, the wires being sufficiently close to [prev]ent the pieces of blubber from passing. The oil, as it drains through this [gra]te, is to be conducted by means of a copper pipe into another back, containing

about the same quantity. When this receiver is full, it is left two or three hours to settle, and then conducted by a sluice into a copper heated by a fire in the usual way. The oil is stirred until it has acquired heat equal to 225° Fahrenheit; this destroys the rancidity, and causes the mucilaginous matter to settle at the bottom. As soon as the oil has received the before-mentioned heat, the fire must be drawn, and about half a tun of cold water pumped upon the surface of the oil, which descending cools the bottom of the copper, and prevents the adhesion of the mucilaginous matter thereto. The oil may then be run off into coolers, and when quite cold be drawn off into casks for use.

Whale oil may, however, be purified, by a system of filtering, without the aid of heat. For this purpose, the long cylindrical bags used by the sugar refiners are sometimes employed. These are about 40 inches long, and 14 inches wide, their mouths being distended by wooden hoops. They are made of stout canvass, lined with flannel; and between these two substances a packing of powdered charcoal, or bone black, is quilted throughout in a stratum of about an inch thick, which detains the gelatinous matter, and other impurities. This oil is received in a cistern, containing water at the bottom to the depth of about 6 inches, in each 20 gallons of which is dissolved about an ounce of blue vitriol, which nearly divests it of the impurities that escaped the filter, and of the unpleasant odour it had before. But it is further cleansed by a second washing, in another cistern of water, wherein it is allowed to remain for several days, and then filtered several times through charcoal; and lastly, by filtering through canvass and flannel without charcoal.

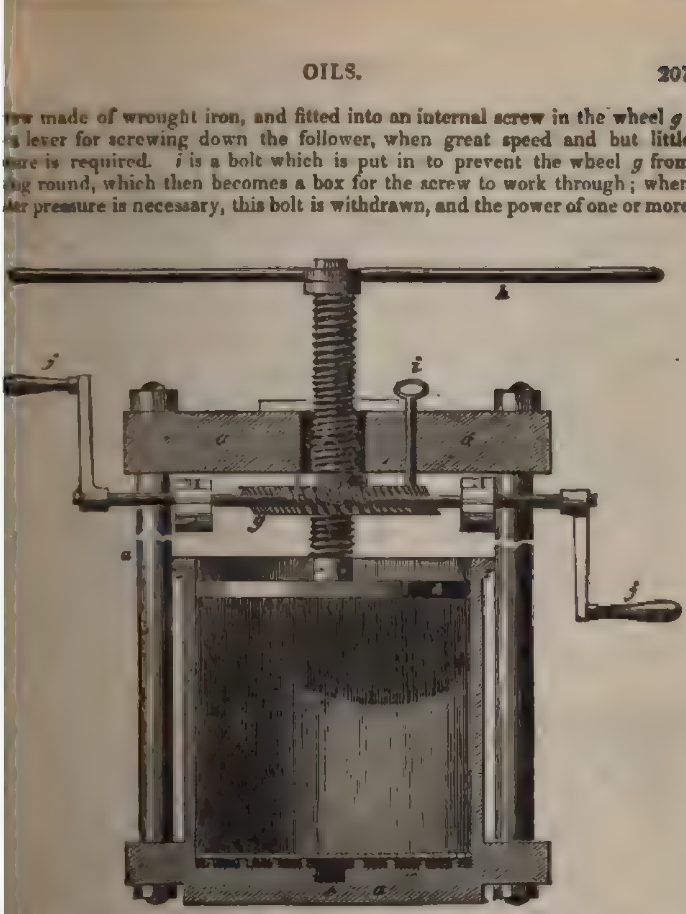
Amongst the numerous papers on this subject that have appeared in the scientific journals, we select the following process, recommended by Mr. Dossie, where the utmost purity is required, and particularly for the woollen manufacture.

"Take a gallon of crude stinking oil, and mix with it a quarter of an ounce of lime slaked in the air, and half a pint of water; stir them together, and when they have stood some hours, add a pint of water, and two ounces of pearl ashes, and place them over a fire that will just keep them simmering, till the oil appears of a light amber colour, and has lost all smell, except a hot, greasy, soaplike scent. Then superadd half a pint of water, in which an ounce of salt has been dissolved; and having boiled them half an hour, pour them into a proper vessel, and let them stand till the separation of the oil, water, and lime be made, as in the preceding process. Where this operation is performed to prepare oil for the woollen manufacture, the salt may be omitted;" but the separation of the lime from the oil will be slower, and a longer boiling will be necessary. If the oil be required yet more pure, treat it after it is separated from the water, &c. according to the second process, with an ounce of chalk, a quarter of an ounce of pearl ashes, and half an ounce of salt."

In the South-Sea fishery, the whalers bring home their oil in casks. In consequence, however, of the wasteful and dangerous nature of the process adopted for obtaining the oil from the blubber, some presses have lately been sent out by the ships to express the oil from the pieces of the blubber that have been boiled, but in which a great quantity of oil still remains. All this oil was formerly allowed to remain in these pieces, called "scraps," and was with them made use of merely as fuel, and burned under the "try-pots" or boilers; but in consequence of the extreme inflammability of the oil, and its great superabundance, serious accidents occurred by the flames issuing from the furnace, and catching the oil in the try-pots. By the use of the subjoined machine (in p. 204) we understand that the danger beforementioned has been obviated, and the oil contained in the scraps, which was before wasted, now forms a sensible portion of a ship's cargo. It is the invention of Mr. John Blythe, an intelligent engineer, of Limehouse.

Description.—*a a a a* is the frame of the press, consisting of a strong cast iron bed and head, and wrought-iron jambs, secured at each end by nuts and screws; *b* is a hollow cylinder, with an iron plate perforated with small holes resting upon ribs in the bottom of the cast-iron cylinder, as shown at *c*; *e* is a spout for allowing the oil to run off; *d* is a follower, also made of cast iron;

...w made of wrought iron, and fitted into an internal screw in the wheel *g*; ...s lever for screwing down the follower, when great speed and but little ...ure is required. *i* is a bolt which is put in to prevent the wheel *g* from ...ng round, which then becomes a box for the screw to work through; when ...ter pressure is necessary, this bolt is withdrawn, and the power of one or more



...applied to the handles *j j*, which turn an endless screw, and give motion to the ..., as shown at *o*; the wheel in its revolution bites upon the underside of ...ad of the press, and consequently forces the screw downwards, with the ...ed power of the endless screw and wheel and main screw. The scraps ...t into the cylinder warm, with a mattress, (wicker basket,) ⅜ of an inch ...n the bottom, to prevent the hard substance from filling up the holes at *e*. ... the press is charged, it is set to work by first screwing down with the ... power of the screw and lever, and finished by adding the power of the ... and endless screw.

...ve *Oil of Laurel*.—This extraordinary and valuable production is sup...to be the only known instance of a perfectly volatile liquid obtainable ... the aid of art. It is yielded by a tree of considerable height, which is ... in the vast forests that cover the flat and fertile regions between the ...oko and the Parime, in South America. The wood of this tree is ...tic, compact in its texture, and of a brownish colour, and its roots ...d with essential oil. The oil is procured by striking with an axe the ... vessels in the internal layers of the bark; while a calabash is held to ... the fluid which gushes out in such abundance, that several quarts may ...ght from a single incision, if the operation be performed with dexterity. ...y respects the native oil resembles the essential obtained by expression, ...tion, and other artificial processes: it is, however, more volatile and ... rectified than any of them, its specific gravity hardly exceeding that of

alcohol. When pure it is colourless and transparent; its taste is warm and pungent; its odour aromatic, and closely allied to that of the oily and resinous juice of the conifera. It is volatile, and evaporates without residuum at the ordinary atmospheric temperature. It is inflammable, and, except when mixed with alcohol, gives out in its combustion a dense smoke. Neither the acids nor the alkalies seem to exert any sensible action upon the native oil; when combined, however, with sulphuric acid, the mixture assumes a momentary brownish tinge, but soon regains its transparency. The oil of laurel dissolves camphor, caoutchouc, wax, and resins, and readily combines with volatile and fixed oils. It is insoluble in water; soluble in alcohol and ether, though the specific gravity of the oil exceeds that of ether; the compound formed by combining them in the proportion of part of the former to two of the latter floats upon the surface of pure ether; and may, therefore, be the lightest of all known fluids. To the chemist, and the vegetable physiologist in particular, native oil of laurel, elaborated by the unassisted hand of nature, in a state of purity which the operose processes of art may equal, but cannot surpass, presents an interesting subject of inquiry, and a wide field of speculation.

The Oil of Birch Bark, which is so much used in Russia for currying eather, to which it gives a peculiar odour, and a power of resisting moisture beyond any other dressing, is prepared in the following manner:—A large earthen pot is filled with the thin white paper-like external bark of the birch-tree, carefully separated from the coarse bark; the mouth of this pot is closed with a wooden bung perforated with several holes. The pot thus prepared is then turned with the mouth downwards, and luted with clay to the mouth of another pot of the same size, which is buried in the ground. The upper pot is now surrounded with fuel, and a fire is made and continued for several hours, according to the size of the pot. When the operation is completed, and the apparatus cooled and unluted, the lower pot is found to contain a quantity of liquid equal to about 60 per cent. by weight of the bark employed; the liquid consisting of a brown oil mixed with pyroligneous tar, swimming in an acid liquor. In some places iron pots have been substituted for the earthen pots, the mouths being separated by an iron plate pierced with holes. The peculiar odour of the oil is supposed to be owing to a resinous matter which is melted out of the bark, and drops into the lower pot during the process of distillation. In conducting this operation on the large scale, a number of these double pots may be placed in the horizontal bed of a reverberatory furnace, with the lower pots imbedded up to their necks in sand; by which arrangement a great economy of fuel and labour will be attained.

For further information on the nature and applications of oil, see the articles Spermaceti, Tallow, Wax, Candles, Fat, Soap, Elaine, Stearin, Ink. (Printers'.) Essential Oils, &c.

OIL-COLOUR CAKES. A convenient preparation for the use of artists, invented by Mr. George Blackman, for which that gentleman was awarded a medal by the Society of Arts. Take, says Mr. Blackman, of the clearest gum mastich, reduced to fine powder, four ounces; of spirits of turpentine, one pint; mix them together in a bottle, stirring them frequently till the mastich is dissolved: if it is wanted in haste, some heat may be applied, but the solution is best when made cold. Let the colours to be made use of be the best that can be procured, taking care that by washing, &c. they are brought to the greatest degree of fineness possible. When the colours are dry, grind them on a hard, close stone, (porphyry is the best,) in spirits of turpentine, adding a small quantity of the mastich varnish. Let the colours so ground become again dry, then prepare the composition for forming them into cakes in the following manner:—Procure some of the purest and whitest spermaceti you can obtain; melt it over a gentle fire in a clean earthen vessel; when fluid, add to it one-third of its weight of pure poppy oil, and stir the whole well together; these things being in readiness, place the stone on which your colours were ground on a frame or support, and by means of a charcoal fire under it make the stone warm; next grind your colour fine with a muller, then adding a sufficient quantity of the mixture of poppy oil and spermaceti, work the whole together;

with a muller to a proper consistence; take then a piece of a fit size for the cake you intend to make, roll it into a ball, put it into a mould, press it, and it will be complete. When these cakes are to be used, they must be rubbed down in poppy, or other oil, or in a mixture of spirits of turpentine and oil, as may best suit the convenience or intention of the artist.

OPERA-GLASS. A short kind of telescope, used chiefly in theatres; it is sometimes called a "diagonal perspective," from its construction. It consists of a short tube, in each side of which there is a hole exactly against the middle of a plane mirror, which reflects the rays falling upon it to the convex glass, through which they are refracted to the concave eye-glass, whence they emerge parallel to the eye at the hole in the tube. This instrument is not intended to magnify objects more than about two or three times. The peculiar artifice is to view a person at a small distance, so that no one shall know who is observed, as the instrument points to a different object from that which is viewed; and as there is a hole on each side, it is impossible to know on which hand the object is situated which you are looking at.

OPIUM. An inspissated gummy juice, which is obtained chiefly from the white poppy of the East (*papaver somniferum*). It may also be obtained, but in a small quantity, from the other species of poppy. It is imported from Persia, Arabia, and other warm parts of Asia, in flat cakes, covered with leaves, to prevent their sticking together. It has a reddish brown colour, and strong peculiar smell; its taste is at first nauseous and bitter, but this soon becomes acrid, and produces a slight warmth in the mouth. In Turkey the white poppy is in great cultivation, for the purpose of affording opium. After the flowering of the plant, when the capsule containing the seed has arrived at its full growth, slight longitudinal incisions are made in the capsules towards the evening. A milky juice oozes out, which is collected the next day. The excess of moisture being evaporated in the sun, it assumes the consistency fitted for making it into cakes in which state it is found in commerce. This is called Turkey opium, to distinguish it from another kind brought from the East Indies, which is generally softer than the Turkey, of a darker colour, less bitter, and more disagreeable to the taste, and has an unpleasant empyreumatic smell. When opium is soft and friable, of a blackish colour, and has an empyreumatic smell, it is bad: its taste should be bitter, but not sweet.

OPOBALSAM. The most precious of the balsams; or that commonly called balm of Gilead. The true balsam is of a pale yellowish colour, clear and transparent, about the consistence of Venice turpentine, of a strong, penetrating, agreeable aromatic smell, and a slightly bitterish pungent taste.

OPODELDOC. A solution of soap and alcohol, with the addition of camphor and volatile oils. It is used, externally, against rheumatic pains, sprains, bruises, and other like complaints.

OPTICS. The science which treats of the nature of light, and the phenomena of vision. Our prescribed limits will not allow of our giving more than a brief outline of the elements of this sublime science, which has employed the pens of some of the most illustrious philosophers in successive ages, whose works upon it are both elaborate and numerous. For the larger portion of the matter on this most interesting branch of natural philsophy, we are greatly indebted to Mr. A. Pritchard, and other modern authors of eminence.

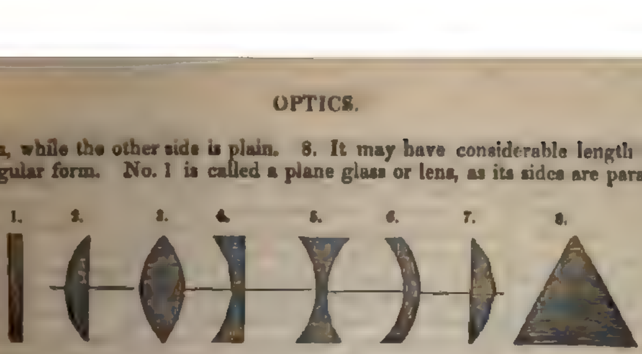
The natural progress of the rays of light is in straight lines; yet, like all other matter, light is influenced by attraction, which sometimes turns it out of its direct course; this happens when it passes out of one medium into another of different density, as from air into water or glass, or from water or glass into air. This disposition or capability of light to be bent, is called its *refrangibility*; and the change of direction actually assumed, when the rays enter another medium, is called *refraction*. A very easy experiment will convince any one that light is influenced by some peculiar law when entering or leaving one medium for another. Put one end of a stick into water, and it will appear as if it were broken. This effect is owing to the rays of light being attracted or drawn out of their direct course on entering the denser medium of the water. It is necessary, however, to observe, that only those rays which enter another medium

obliquely, suffer refraction; for rays which fall perpendicularly are equally attracted on all sides, and, therefore, have no tendency to deviate in any direction. If a shilling, or any other conspicuous but small object, be placed at the bottom of a basin, and the spectator retire to such a distance that the edge of the vessel just prevents its being seen, and the vessel be then filled with water, the shilling will become perfectly visible, though neither it nor the spectator change their place in the slightest degree. In this experiment the spectator looks at the shilling in an oblique direction, and the rays proceeding from it, by which it is rendered visible after the water has been poured in, are bent towards his eye on entering the air. The greater the density of any medium, the greater is its refractive power; and of two refracting media, that which is of an oily or inflammable nature, will have a greater refracting power than the other. The *incident angle* is the angle made by a ray of light and a line drawn perpendicular to the refracting surface, at the point where the ray enters the surface; and the *refracted angle* is the angle made by the ray in the refracting medium, with the same perpendicular continued. The *sine* of the angle is a line which serves to measure the angle, being drawn from a point in one leg, perpendicular to the other. In the subjoined figure A C D is the *incident* angle, H C E the *refracted* angle, and B C H the angle of *deviation;* A F is the sine of the angle of incidence; and H G the sine of the angle of refraction. It may seem extraordinary that light should pass more directly through a dense than through a rare medium; but it has been ascertained that light is subject to attraction; and Sir Isaac Newton discovered and demonstrated that this power is the cause of refraction. The truth of this theory is confirmed by the fact, that the change in the direction of the ray commences, not, as might be supposed, when it comes in contact with the refracting medium, but a little before it reaches the surface; and the incurvation augments in proportion as it approaches the medium.

The term *lens* is given to any transparent substance, as glass, crystal, water, or diamond, having one or both surfaces curved to collect or disperse the light transmitted by it. The lenses in general use are made of glass, and are usually called magnifying glasses. Glass, however, does not possess a greater share of the magnifying property than other transparent substances. Mankind have availed themselves of the principle of refraction to excellent purpose in the construction of lenses; for, by grinding the glass or other substance thinner at the edges than in the middle, those rays of light which would strike upon it in a straight line, or perpendicularly, if it were plain, strike upon it obliquely, and the refraction they suffer, causes them to *converge;* on the contrary, by making the glass thinner in the middle than at the sides, the rays are refracted the contrary way, and, therefore, become *divergent.* The nature of refraction through lenses may, perhaps, be rendered more clear, if we reflect that all curved surfaces are composed of straight lines or points, infinitely short, and inclining to each other like the stones in the arch of a bridge. When parallel rays fall upon a surface of this sort, it is evident that those only which enter the middle part will go on in a straight direction; those which strike the sides will strike them obliquely, and will, consequently, be made to converge. If the surface be a perfect curve, it is clear that only the ray that strikes the centre of the curve will enter it in a straight direction; all the rest will be more or less refracted, according to the degree of obliquity with which they strike the surface, and the whole of the refracted rays will converge to a point called the focus.

Glasses, or lenses, are usually ground for optical purposes into eight different forms. 1. The lens may be flat on both sides, like the pane of a window. 2. It may be flat on one side, and convex on the other. 3. It may be convex on both sides. 4. It may be flat on one side, and concave on the other. 5. It may be concave on both sides. 6. It may be convex on one side, and concave on the other. 7. It may have one side, which must be convex, ground into little

facets, while the other side is plain. 8. It may have considerable length in a triangular form. No. 1 is called a plane glass or lens, as its sides are parallel;



No. 2, a plano-convex lens; No. 3, a double convex; No. 4, a plano-concave; No. 5, a double concave; No. 6, a meniscus; No. 7, a multiplying glass; and No. 8, a prism. The term *lens* is usually given to such glasses or substances only as either magnify or diminish. Nos. 2, 3, 4, and 5, are therefore lenses; No. 6 is also a lens when its surfaces are portions of different spheres; but when they are of equal radii, or parallel, it has only the effect of a plane glass. A ray entering the plane glass, No. 1, will be refracted; but it will undergo another refraction on its emergence, which will rectify the former; the place of the object will, therefore, be a little altered, but the figure will remain the same. Suppose A B, *Fig.* 1, to represent a solid piece of glass with two parallel surfaces, an incident ray E F will be refracted into F G, and F G will be refracted on passing from the second surface into G H, parallel to the original direction E F. If parallel rays enter the plano-convex glass, as shown by

Fig. 1.

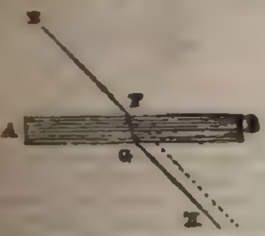


Fig. 2.

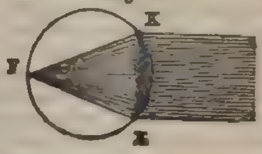
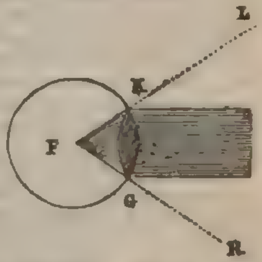


Fig. 2, the ray E will be refracted upwards to F, and the ray K will be refracted downwards to the same point; there they will cross, and then go onward in a straight line, and continue to diverge till intercepted by some obstacle.

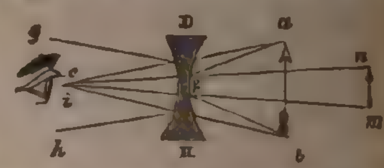
When parallel rays fall upon a double convex glass, K G, they will be refracted still more abruptly, and meet sooner in a point or principal focus at F. The distance of this focus is equal to the semi-diameter of the circle which the convexity of the glass continued, would produce. Either this glass or the former, as they collect the rays of the sun into a point, will burn at that point, the whole force of the rays that pass through them being concentrated there.



From all luminous objects, the rays of light proceed in a state of divergence; but when the distance from which they come is very great, the quantity of divergence is too small to require notice. The fixed stars and the sun, for example, are so immensely distant, that their rays are always considered as parallel; and it is only parallel rays which are converged to a focus in the manner described. Divergent rays proceeding from a point, as the flame of a candle, will be differently affected. If, therefore, a candle be placed exactly at the focal distance of a single or double convex

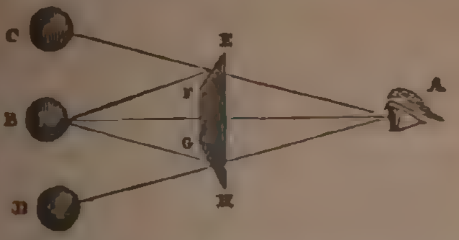
lens, the rays will emerge parallel to each other. If the candle be placed nearer to the glass than its focal distance, the rays, after passing through the glass, will no longer be parallel, but separate or diverge. If the candle be placed still further off, the rays will then strike the glass more nearly parallel, and will, therefore, upon passing through, converge or unite at a distance behind the glass, more nearly approaching the distance at which parallel rays would be converged. After the rays have united in a focus, they will cross each other, and form an inverted picture of the flame of a candle, which may be received on a piece of paper placed at the meeting of the rays behind. The cause of the inversion of the image is evident, the upper rays being those which come from the under part of the luminous body; and the under rays, on the contrary, coming from the upper part.

In looking through a plano-convex or double convex lens, the object appears magnified agreeably to the rule, that we see every thing in the direction of the lines in which the rays last approach the eye; consequently, the larger the angle under which an object is seen, the larger that object will appear. From lenses the reverse in form to those we have noticed, we naturally expect opposite effects; accordingly, the attractive and refractive powers of a plano-concave and double-concave lens are not towards the centre, but towards the circumference. Parallel rays falling upon these lenses diverge, or are dispersed. Rays already divergent are rendered more so, and convergent rays are made less convergent; hence objects seen through one of these glasses appear smaller than to the naked eye. Let *a b*, in the subjoined figure, represent an arrow, which would be seen by the eye, if no lens were before it, by the convergent rays *a c b i*; but if the double-concave glass D H be interposed between the object and the eye, the ray *a c* will be bent towards *g*, and the ray *b i* will be bent towards *h*, and consequently both will be useless, as they do not enter the eye. The object, then, will be seen by the rays *a o b r*, which, on entering the glass, will be refracted into the lines *o c* and *r i*; and, according to the rule laid down, the object will be seen in the last direction of these rays; therefore, as the angle *o c r* is so much smaller than the angle *a c b*, the arrow necessarily appears diminished; and as, with the diminution of its apparent size, we connect the idea of its being further off, it seems to be at the distance *n m*.



The miniscus acts like a convex lens when it is thickest in the middle, that is, when its convex surface is a portion of a less sphere than its concave one; on the contrary, when it is thinnest in the middle, or has its concave surface a portion of a less sphere than the other, it has the effect of a concave lens. The axis of a lens, is a line supposed to be drawn through the centre of its spherical surfaces. When one side of the lens is plane, the axis is perpendicular to that side. The axis of a lens continued, would pass exactly through the centre of that sphere, of which the lens is the segment. The focus of a plano-convex lens is at a distance from the convex surface equal to the diameter of the sphere of which it is a part; and that of a double and equally convex lens is at half the same distance. The distance of the focus of a solid globe or ball of glass is one quarter of its diameter from the nearest part of the ball. To explain the effect of the multiplying glass, (No. 7,) it will only be necessary to revert to the principle, that objects appear in the direction of the line last described by the rays that render them visible; hence, if the object B, (p. 213.) is seen through the glass E H by the ray B A that passes through the surface F G, the object, by the eye at A, will be seen at B; the ray B G passes through the surface G H, and after refraction comes to the eye in the direction of A D, as it proceeded from D, and therefore the object appears at D; and for the same reason, through the surface F E, it appears at C; consequently, there will be the appearance of as many objects as there are flat surfaces on the glass, for-

each of them shows the same object in a different place. The disposition of the rays of light to be turned back into the medium from whence they came, is



called their *reflexibility*; the change of direction produced by their being actually turned back, is called *reflection*. All objects which are not themselves luminous are rendered visible by reflection; and glass, crystal, water, and the most pellucid media, reflect a portion of the rays of light which fall on them, or their forms and substance could not be distinguished. On the other hand, the whole of the incident light is not reflected from any surface, however bright, smooth, and opaque. It is calculated that the best mirrors reflect little more than half the light they receive; the part lost consists of two portions, one of which, and by far the largest, being absorbed by the mirror, and the other, scattered by irregular reflection. Light is always lost, in passing through the most transparent bodies, by the same laws.

The different refrangibility of the rays of light is demonstrated by the prism. If a beam of light from the sun be let into a darkened room, and be received upon a white screen or opposite wall, it will form a circular image, and will be of one uniform whiteness. If a prism be interposed, so that the light must pass through it before it reaches the wall, the image is no longer circular or white; it assumes an oblong shape, terminated by semicircular arches, and exhibits seven different colours. This oblong image is called the spectrum. In the whole range of philosophical experiment, a more beautiful appearance cannot be presented to the eye, and instructive nature will appear not less extraordinary than its beauty, when it is considered, that the investigation of the cause of it led Sir Isaac Newton to form the first rational theory of the cause of colours. The seven colours of the spectrum are called the original, or primary colours. If a spectrum be divided into 100 parts, the red part of it is found to occupy 11 of these parts; the orange 8, the yellow 14, the green 17, the blue 17, the indigo 11, and the violet 22. The red part of the spectrum is nearest the prism; and the violet, at the greatest distance. It is clear, from this, that light is not homogenous, because the attractive power of the prism is greater upon some parts of it than upon other parts. Accordingly, it is generally concluded that the solar beam or white light is composed of particles differing in size and density; that this difference of their size and density is the cause of their being differently refrangible; and that the separation of the rays of one or more sizes from the rest, by various means, produces all the diversity of colours which affect our sight. It is found, that the red part of light is capable of struggling through thick and resisting mediums, when all the other colours are stopped. Thus, the sun appears red when seen through a fog. The particles which compose orange light are next, in size and refrangibility, to the red, and so on to the violet, which consists of the smallest particles, and which are, therefore, the most turned out of their course. White is composed of all the primary colours, mixed together in their due proportions. When bodies reflect the rays of light in the proportion in which they exist in the solar beam, they appear white; when they reflect none of the rays, they appear black.

Convex lenses in their simple state have been applied to collect the heat of the sun's rays, for purposes similar to those of burning mirrors. A burning

lens must be convex; a burning mirror, concave; because both produce their effect by concentrating into a focus the rays of light and heat incident upon a large surface. As the rays which pass through a convex lens, or are reflected from a concave mirror, are united at its focus, their effect is so much the greater, as the surface of the lens or mirror exceeds that of the focus. Thus, if a lens four inches in diameter collect the sun's rays into a focus at the distance of one foot, the focal image will not be more than one-tenth of an inch broad. The surface of this circle is 1600 times less than the surface of the lens, consequently the density of the sun's rays within it is proportionately increased. It has been found, that large lenses and mirrors burn with irresistible intensity when properly constructed, dispersing the hardest metals and other substances into gas, often in a few seconds. See Burning Glass, and the various other optical instruments, under their respective names.

ORES. The natural bodies whence metals are extracted. Metallic substances, when found pure, are called native; but when combined with other substances, as they generally are, they are denominated ores. As it is of the utmost importance to be acquainted with the materials of which ores are composed, as well as the simplest and easiest processes by which they may be separated from each other, we deem it necessary to give the following brief account of the modes of reduction usually adopted.

Ores of Gold.—Gold exists in nature only in the metallic state; but it is scarcely ever found perfectly pure, for it is alloyed in different proportions with silver, copper, tellurium, and some other metals. When it is alloyed with silver or copper, or even with both, the gold retains its ductility; but when combined with tellurium, its distinctive characters entirely disappear. The presence of gold may easily be detected by treating the mineral supposed to contain it with nitro-muriatic acid, and dropping muriate of tin into the solution. If the solution contains any gold, a purple precipitate immediately appears. Native gold ought to be dissolved in nitro-muriatic acid; the silver, if any is present, falls to the bottom in the state of muriate, and may be separated by filtration, and weighed. Pour sulphate of iron into the solution, and the gold is precipitated in the metallic state. The copper, if any is present, may be precipitated by means of a plate of iron; the presence of iron may be ascertained by dropping tincture of nutgalls into a portion of the solution. The auriferous pyrites may be treated with diluted nitrous acid, which dissolves the iron, and separates the sulphur; the gold remains insoluble, and is found in the state of small grains. In the Hungarian gold mines, which are the richest yet known in the old continent, the attention of the miner is not merely limited to the strings of ore, but to the whole contents of the vein, which are usually extracted, and raised to the surface in large masses. These masses are distributed to the workmen, who break them down, first with large hammers, and afterwards with smaller ones, till they are reduced to pieces of the size of a walnut; the native gold, with the matrix attached to it, is again to be broken by hand into still smaller pieces, by which means other impurities and stony matters are separated. The ore is then introduced into a wooden box, floored with cast-iron plates, and, by the action of two or more heavy spars of oak, which are shod with iron, and alternately worked like the common stamping mill, it is reduced to a fine powder; this powder, which is called flour, is then removed into a vessel like a large basin, and mixed with such a quantity of salt and water as will render it damp; the workman then takes a thin, porous leather bag, introduces a quantity of mercury into it, and, by regular and continued pressure, forces the mercury, in very minute drops, through the leather. In this divided state it falls upon the pulverized ore, and is immediately kneaded up with it, till the requisite quantity, which depends on the proportion of gold, has been added. After completing this part of the process, the next object is to incorporate the mercury and gold; this is effected by rubbing the mixture together for some time by means of a wooden pestle; the mixture is then heated in a proper vessel, and subjected, for three or four days, to the temperature of boiling water; and, lastly, the mixture is to be carefully washed by small parcels at a time, so that the earthy particles may be carried off by the water; the mercury, combined with the gold, only remains

behind in the form of amalgam. A portion of this mercury is then separated by pressure, in a leathern bag, and the remainder is driven off by distillation, leaving behind the gold and silver, with which it may be alloyed. When this metal is found in other ores, they are first roasted, to disperse the volatile principles, and to oxidize the other metals. The gold, which is but little subject to oxidation, is extracted by amalgamation or by cupellation, or either methods, adapted to each ore, according to its properties or constituent parts. The metal obtained in these ways is always more or less alloyed, particularly with silver and copper. The first step in its purification is the process of cupellation. (See Cupellation.) The gold, after it has been submitted to this process, is often alloyed with silver, which, being nearly as difficult of oxidation, is not removed by the action of lead: and hence the necessity of the operation denominated *parting*, for which see Parting.

Ores of Platinum.—The whole of the platinum which has been brought to Europe, has been previously subjected to the process of amalgamation in South America: and hence it happens that a small quantity of mercury remains in it. In treating the ores, therefore, the first object is to separate the mercury by means of heat, either in an open ladle, or in an earthy retort; the platinum remaining after the mercury is thus driven off, appears much yellower, because the particles of gold dispersed through it exhibit their peculiar colour. Proust's method of analysis is, first, to separate the sand with which the grains of platinum are mixed, by exposing them to a blast of air. By heat he evaporates the mercury, which still adheres to them, and then picks out the grains of gold, which are always mixed with platinum, and which are thus rendered visible. The ore is then dissolved in an acid composed of one part of nitre, and three parts of muriatic acid; a black powder remains: this powder, when roasted, gives out phosphorus and sulphur. After the separation of the gold, nitro-muriatic acid being poured on the remaining mass will dissolve it, with the exception of a small quantity of black matter, which was formerly mistaken for plumbago, but is now proved to be a compound of osmium and iridium, two of the four new metallic bodies, which were discovered a few years ago by Mr. Tennant. These two metals Dr. Wollaston has since shown to exist also in the crude platinum ore, united together in the form of distinct minute crystals, and dispersed through the other grains, from which they can be distinguished and picked out without difficulty. Muriate of ammonia being now added to the solution, the platinum is precipitated in the form of a yellowish powder, which is a compound of muriatic acid, ammonia, and platinum: the remaining solution, after the platinum has been separated from it, still contains, besides iron, minute quantities of various other substances, amongst which the two other metallic bodies, palladium and rhodium, were discovered by Dr. Wollaston. Having now brought the platinum to the state of salt, the next object is to restore it, thus purified, to its metallic state, and to consolidate it into a malleable mass; this, from the great infusibility of platinum, has long been a matter of considerable difficulty and labour. It had been long discovered that arsenic readily united with platinum, and formed with it an alloy of great fusibility; an alloy, therefore, was made of crude platinum and arsenic; and the latter metal, being easily volatilized, was driven off by heat, whilst the iron, being oxidated during the process, was also separated from the mass; so that the platinum was left in an impure but malleable state.

Ores of Silver.—The analysis and reduction of these different ores, it is scarcely necessary to observe, must be conducted according to the nature and properties of the ingredients which enter into the composition of the ore to be examined or reduced. **Pure native silver requires no other assay than fusion**, with a little potash to free it from its earthy matter. In the humid way, the silver may be dissolved in nitric acid, and precipitated by common salt; the precipitate may then be fused with soda in a crucible, by which the silver is obtained pure, and the muriate of soda sublimed. The auriferous silver ores may be treated with potash, by fusion in a crucible; the alloy of silver and gold is first obtained, and the two metals may be separated by the process of parting. Those ores which consist of silver combined with antimony, or arsenic, or both,

are first roasted, to drive off the arsenic and antimony, the silver remaining pure. The process is much facilitated by the use of nitre, for the purpose of oxidating the metals to be dissipated. The ores of silver are reduced either by fusion or amalgamation; the former method is chiefly practised on native sulphuret of lead or galena, which commonly contains a portion of silver, and often in such quantity as to make its separation from the lead a profitable undertaking. After the lead has been extracted from the ore, the object of the refiner is to obtain the silver in a separate state, which is dispersed through the mass of lead; this is performed by the process of cupellation on a large scale, or refining, as it is usually termed. The other process of reducing silver ores by amalgamation is now pretty generally followed in different parts of Europe. The ores which are subjected to amalgamation are such as contain only a small quantity of lead or copper; but it is of some importance that there should be a certain proportion of iron pyrites; and if this proportion be not naturally mixed with the ore, it is a good practice to supply the deficiency by adding what is wanting to the dressed ore, so that the pyritical contents may, as nearly as possible, be in a certain proportion to the quantity of silver, which is to be ascertained by previously assaying a portion of the ore. The ore being reduced to the consistence of coarse sand, is carefully mixed with common salt, in the proportion of eight or nine per cent.; when the silver in the ore amounts to eight ounces per quintal, and when the latter amounts to thirty-two ounces, or even a greater proportion, from ten to twelve per cent. of salt is to be added. The next process is roasting the ore, in which about three quintals are spread on the floor of a reverberatory surface, and subjected to a moderate red heat. During the roasting, the ore is to be turned twice or thrice, that every part of it may be equally exposed to the heat. When the whole of the ore is roasted, it is ground in a mill and passed through sieves, by which it is made as fine as meal, and is then prepared for the proper process of amalgamation; this is performed in the following manner:—A number of small barrels, which are made to revolve rapidly on their axis by means of machinery; or fixed tubs, either open or covered, having in the centre of each an instrument resembling a chocolate mill, which may be turned rapidly by similar machinery; the tubs or barrels are filled about one-third with water, and, afterwards, a sufficient quantity of roasted ore and mercury, in nearly equal proportions, is introduced, so that the whole may be of the consistence of thin mud. The machinery is put in motion, and continued without interruption, for thirty or forty-eight hours, according to the nature of the ore, when the amalgamation is completed. About a quarter of an hour after the agitation of the matter in the barrels has ceased, the greater part of it falls to the bottom, and is withdrawn by opening a hole made for the purpose; the earthy residue is carefully washed by small portions at a time, and thus a good deal of the amalgam, which, from being very minutely divided, could not sink through and mix with the rest, is recovered. The earth, however, if originally rich in silver, still retains a small proportion; it is, therefore, dried, and being mixed with about three per cent. of salt, is again roasted, but at a higher temperature than at first; and the process of amalgamation being again repeated, the whole of the silver is extracted. The fluid amalgam is strained through a closely woven bag, and is thus separated into nearly pure mercury and a stiff amalgam; and the latter being subjected to distillation, the mercury is driven over, and the silver remains behind: the copper, which is combined with the silver, is separated by cupellation.

Ores of Mercury.—These present less variety than those of many other metals, and on account of the peculiar properties of the metal, the management of its ores, whether for the purposes of analysis or reduction, is less complicated and difficult. In order to analyse the ore of native mercury, or native amalgam, it may be dissolved in nitric acid. The gold, if any is present, remains in the state of powder, and may be estimated by its weight. The affusion of water precipitates the bismuth, if the solution happens to contain any. Common salt precipitates the silver, and also part of the mercury, but the latter may be redissolved by a sufficient quantity of water, or, which is far better, of oxymuriatic acid, while the muriate of silver remains insoluble; lastly, the mercury may be

precipitated by sulphate of iron, and estimated. Native cinnabar may be treated with a mixture of three parts muriatic, and one part nitric acid, which dissolves the mercury, and leaves the sulphur. Muriate of mercury may be digested in muriatic acid, till the whole is dissolved. Muriate of barytes precipitates the sulphuric acid, 100 parts of which are equivalent to 186 of sulphate of mercury, and the proportion of this salt being known, we have that of the muriate. A very simple process is followed for reducing the ores of mercury; the best and most scientific method is that practised at the mines of Deaux Ponts and Poria. The ore, as it is brought out of the mine, is carefully sorted by the hand, and those parts which seem destitute of metal are rejected. It is next reduced to powder, and accurately mixed with one fifth of quicklime, which has fallen to powder by exposing it to the air, the quantity of quicklime being regulated by the proportions of cinnabar contained in the ore. The mixture being thus prepared, is introduced into iron retorts, which are capable of holding about sixty pounds weight. The retorts, to the number of forty or fifty, are fixed in a long furnace, and a glass receiver is attached to each, but it is not luted. A moderate heat is then applied, for the purpose of driving off the whole of the moisture, and when this is done, the joinings of the vessels must be closely stopped with tempered clay, and a full red heat is to be applied, and continued for seven or eight hours, at the end of which time the whole of the mercury will be volatilized, and condensed in the receiver. By this process, it is found that from six to ten ounces of metal are produced from one hundred pounds of the ore.

Ores of Copper.—This metal is found native in the state of oxide, in the state of sulphuret, and in that of salt, combined with carbonic, muriatic, phosphoric, and arsenic acids. Native copper sometimes contains gold, silver, or iron. It may be dissolved in nitric acid: the gold remains in the state of a blackish or rather violet-coloured powder; the silver may be separated by a polished plate of copper (or it may be precipitated from a separate portion of the solution by common salt); the iron may be separated by boiling the solution to dryness, and treating the residuum with water. By this process, the nitrate of iron is decomposed; the oxide of iron remains, while the water dissolves the nitrate of copper; this last salt may be decomposed by boiling it with potash; the precipitate dried in a red heat is black oxide of copper; one hundred parts of it denote eighty of the metallic copper. Sulphuret of copper may be dissolved in dilute nitric acid, part of the sulphur remains unaltered, and may be estimated by weighing it, and burning it off; part is acidified, and may be precipitated by nitrate of barytes, 100 parts of the dried precipitate indicating 14.5 of sulphur. By evaporation to dryness, and solution in water, the iron is separated, and the copper may be estimated as in the last paragraph, or muriatic acid may be used instead of nitric acid, but in that case it is more difficult to obtain a complete solution. The usual process employed in our Cornish mining districts, for reducing copper ores to the metallic state, are described under the article COPPER, (which see.)

Ores of Iron.—Notwithstanding the great variety of iron ores, they may be all, so far as analysis is concerned, arranged under three heads; namely, sulphurets, oxides, and salts. The first are distinguished by their general bronze colour, but more particularly by the suffocating smell of sulphureous acid gas, which they afford by being heated to redness in the open air. The second consist of iron united with oxygen, and are by far the most common of all. Nearly the whole of the iron ores in use are of this kind, containing also different proportions of earthy matter in their composition. The third division comprehends such as consist of the oxide of iron combined with some acid, and hence are called salts; the principal varieties of these are the phosphates, sulphates, arseniates, and carbonates. The various processes employed at our great iron works for the reduction of the different species of iron ore, are given under the article IRON.

Ores of Tin.—Tin-stone, or vein tin, as it is called in Cornwall, contains a large proportion of stony matters; it therefore requires considerable care in its preparation, previously to its being reduced. It is first broken by hammers into pieces about the size of a hen's egg, when it is ready for the operation of stamp-

ing, which is performed in the way already described for the ores of gold excepting that there are only three stampers. A tin plate of about a foot square, and pierced with holes, to admit a moderate sized knitting needle, is inserted in front of the trough, and that surface of the plate with the rough extremities of the holes is on the inside, by which the holes are prevented from being plugged up with the ore. As the ore is reduced to the proper fineness, it passes with the water through the holes into the labyrinth where it is collected, and after being washed on a wooden table, it is ready for roasting. In this state it has a considerable proportion of copper and iron pyrites, and is called black tin; after being calcined, at a low red heat, for several hours in a large reverberatory furnace, the ore comes out of a bright ochrey red colour, owing to the decomposition and oxidation of some of the metallic substances; but the oxide of tin, when the operation is properly conducted, remains unaltered. The ore is washed a second time, to separate the remaining impurities, and the water, which is impregnated with sulphate of copper, is retained, and decomposed by means of old iron. The reduction of the ore is the next step in the process, seven cwt. of roasted ore, with one fifth of its bulk of small coal, are introduced into a reverberatory furnace, which is about seven feet long, and three and a half wide—no lime, or, indeed, flux of any kind, is required. A brisk heat is kept up for about six hours, the tin sinking down as it is reduced, and covered with black scoriæ. The furnace is now tapped, and the metal flows into a shallow pit; when the whole of the metal has run out, the scoriæ are removed from the furnace, and a fresh charge is made. The metal in the pit throws up a slag, rich in metal, which is immediately returned into the furnace, and after the melted tin has cooled a little, it is taken out with ladles, and poured into granite moulds; each charge affords on an average from four to five cwt. of metal, but as the first scoriæ are not entirely free from metal, they are again stamped and washed, and mixed with a new parcel of roasted ore. The pigs of tin are next put into a small reverberatory furnace, where, without any addition, they are subjected to a very gentle heat; the purest part of the tin melts first, and is drawn off, forming what is called common grained tin; the other part contains some copper, arsenic, and iron, which is brought to a state of fusion, and cast into pigs, forming common tin.

Ores of Lead.—The methods of reducing lead ores have been given under the article Lead. See also Separation.

Ores of Bismuth.—Bismuth is accompanied by native silver, galena, some other metals, and earthy substances. In conducting the analysis, previous roasting is not requisite. The low degree of heat at which bismuth is fusible renders the reduction of the ores of this metal a very simple process. In the large way, the ores were formerly reduced merely by heating them along with burning fuel; sometimes a shallow hole was made in the ground, and filled loosely with pieces of wood and bushes, and after the fire was kindled, the ore, reduced to small pieces, was thrown in; sometimes the stump of a hollow pine tree was filled with wood and ore alternately, and set on fire, the bismuth separated from its matrix, and collected in a mass at the bottom; the scarcity of wood has, however, put an end to these rude and extravagant methods, and the ores of bismuth are now reduced in a common reverberatory furnace, the bed of which is lined with charcoal, whence the melted metal is removed in iron ladles, and cast into masses weighing twenty or thirty pounds, in which state it is brought to market.

Ores of Zinc.—The ores of zinc are the native carbonate, or common calamine, the oxide of zinc and blende, or the sulphuret of zinc. In the process for reducing the ore of zinc, it is first to be broken into small pieces, and the different impurities being separated, it is next calcined in a reverberatory furnace, at a moderate red heat; and if the ore be calamine, the carbonic acid is driven off, and if blende, it is deprived of its sulphur. After this it is washed, and the metallic oxide being separated from the earthy parts, it is dried, and carefully mixed with about one eighth of its weight of charcoal, by grinding the ingredients together in a mill, and is now ready for the smelting process. This is performed in a circular furnace, in which are fixed six large earthen pots,

about four feet high, and nearly in the shape of oil jars. An iron tube is inserted into the bottom of each pot, and passing through the arched floor of the furnace, terminates in a vessel of water placed beneath, while the other end of the tube rises within the crucible to a few inches of the top. The crucibles are then filled with the mixture of the ore and charcoal, to the level of the tube; the cover of each is carefully luted on, and an intense heat is to be kept for several hours. The zinc, as the process of reduction goes on, rises, in the form of vapour, to the top of the pot, but as it cannot escape, it descends through the iron tube, passes into the water, and is condensed in small drops. The globules are afterwards fused, and cast into the form of ingots, when it is fit for the market; but as common zinc contains a little of other metals, as copper, lead, arsenic, iron, and manganese, which impair its quality, these impurities are partially separated by melting the zinc in a crucible, and stirring into it, with a stick or earthen rod, a mixture of sulphur and fat; by the latter, the zinc is preserved from oxidation, and the sulphur combines with the other metals, except the zinc, and, converting them into sulphurets, they rise to the top in the form of scoriæ, which may be removed. This process is to be repeated as long as any scoriæ appear. See ZINC.

Ores of Antimony.—The sulphuretted ore of antimony is the only one which is found in sufficient quantity to be employed in the process of reduction in the large way, and the process it undergoes is extremely simple. The ore, being separated from the greater part of the stony matters which adhere to it, is placed on the bed of a reverberatory furnace, and covered with charcoal powder, and being brought to a low red heat, the sulphuret enters into fusion, and the earthy parts floating on the surface, are removed with a rake. The melted part is cast into the form of large cakes, and is the crude antimony of the shops. The metal is obtained in a state of purity from the crude antimony or sulphuret, by different processes. After its reduction to a pure state, it has been long known by the appellation of regulus of antimony. In the reformed chemical nomenclature, indeed, it is now called simply antimony, but the term regulus still continues to be used by the merchant or the artisan. (See ANTIMONY.) The ores of *Cobalt, Nickel, Arsenic, Titanium,* and *Manganese,* are noticed under their metallic heads.

ORGAN. A large and very harmonious musical instrument, of considerable antiquity. They were first introduced into this country about the fourteenth century, although instruments of a similar nature, but of a less refined construction, were in use long prior in some of the cities of the southern and western parts of Europe. During the civil wars they were removed from the churches in England, and so generally reprobated that there could scarcely be found either organists or organ-builders; but after the Restoration, owing to the deficiency of workmen and musicians, liberal encouragement was offered for the introduction of foreign talent, and the re-establishment, at home, of our native emigrants. The most conspicuous of those who, in consequence, came over to minister to the public taste, were Bernard Schmidt (afterwards distinguished by the name of Father Smith) and Renatus Harris; and, it appears, these two individuals were so nearly matched in ability, that several public trials were made to determine whose instrument was entitled to superior estimation, which was finally adjudged to Father Smith. In the *Universal Magazine* for 1778, a quaint account is given of this controversy from the pen of an anonymous correspondent. This occurred during the reign of Charles II.; and of the organs that were constructed at that period by Harris, several fine ones are said to be remaining in London; namely, that of St. Bride, St. Lawrence, and St. Mary Axe. Of those constructed by Father Smith, may be enumerated that for St. Paul's, St. Mary Woolnoth, the Temple Church (where the contest took place), St. Mary, Oxford, and Trinity College, Cambridge; all of which have been highly celebrated for their tone and the variety of their powers, embracing the vox humana stop, the cremona, the flute, and many others. It is, indeed, considered by many reputed judges, that these old instruments far surpass in tone any of more modern construction notwithstanding the great improve-

ments in the mechanism of organs by Byfield, Snetzler, Green, Gray, Fligh, and others.

The modern organ is a very complicated and ingenious piece of mechanism. Although it is spoken of as one instrument, yet, strictly speaking, it is a collection of instruments, all brought under the fingers of one performer; and is contrived, that he has it in his power to play on any one singly, or to combine several, or all, according to his taste, in order to produce variety of effect: it consists, even in its simplest form, of a number of sets of pipes, each producing the twelve notes of the chromatic scale, and comprising several octaves, according to the usual key-board. The magnitude and grandeur of these instruments chiefly depend on the number and variety of the stops and sizes of the pipes, so that the difference of effect which it is in the power of an able organist to produce is almost endless. To give a particular detail of the construction of organs, would scarcely accord with our prescribed limits, and would, in a great measure, be a repetition of many of the parts described under the head of APOLLONICON; we shall, therefore, close the subject in this place, by referring the reader to our account of the latter instrument, and to the article ORGAN, in the *Oxford Encyclopædia*, which contains much interesting information on this subject, with several engravings, explanatory of the mechanism of the several kinds of organs.

ORPIMENT. A mineral substance, consisting of arsenic combined with about forty-three parts of sulphur, and is about thrice as heavy as water. It is found, both in a massive and crystallized state, in Turkey, Hungary, and some other countries. The orpiment of commerce is an artificial production, chiefly imported from different parts of the Levant. A beautiful, but fugitive pigment, called *king's yellow*, is prepared from this mineral. (See PAINTING.)

ORRERY. An astronomical instrument, for exhibiting the motions of the heavenly bodies, was first constructed by Graham; but its name is derived from one made by Howley for the Earl of Orrery. It is now generally called PLANETARIUM, (which see.)

ORRIS-ROOT. The root of a white-flowered kind of iris, called *Florentine Iris*, which is a native of Italy, and is distinguished by having two flowers on each stalk; the petals bearded, and the leaves sword-shaped. In a dried state this root is well known on account of its grateful odour, which somewhat approaches that of the violet. It is consequently much used in the manufacture of hair-powder, and other articles, for which an agreeable scent is required. It is sometimes employed in medicine as a pectoral or expectorant, and sometimes in dropsies. In a recent state, the root is extremely acrid; and, when chewed, excites in the mouth a pungent taste, which continues for several hours; but this acrimony is almost wholly dissipated by drying. Orris-root is chiefly imported into this country from Leghorn.

OSCILLATION, *Centre of*. That point, in a body vibrating by its gravity, in which, if any body be placed, or if the whole mass be collected, it will perform its vibrations in the same time, and with the same angular velocity, as the whole body, about the same point or axis of suspension. The centre of oscillation may be thus found: suspend the body by the given point, so that it may vibrate freely in small arcs, and count the number of vibrations it makes in a minute; then will the distance in inches, of the centre of oscillation, be equal to the number 140,850, divided by the square of the number of vibrations. Thus, suppose any irregular body were set in vibration, and made 30 vibrations in a minute, then $\frac{140850}{30^2} = 156\frac{1}{2}$ inches. The number 140,850 is obtained by multiplying $39\frac{1}{8}$ inches, the length of a seconds pendulum, by the square of 60, the number of vibrations it makes in a minute.

OSMIUM. A metal lately discovered by Mr. Tennant among platina, and thus called by him, from the pungent and peculiar smell of its oxide. The pure metal, previously heated, did not appear to be acted upon by acids. Heated in a silver cup, with caustic alkali, it combined with it, and gave a yellow solution similar to that from which it was procured. From this solution, acids separate the oxide of osmium.

OVEN is a general term applied to variously formed apparatus employed for

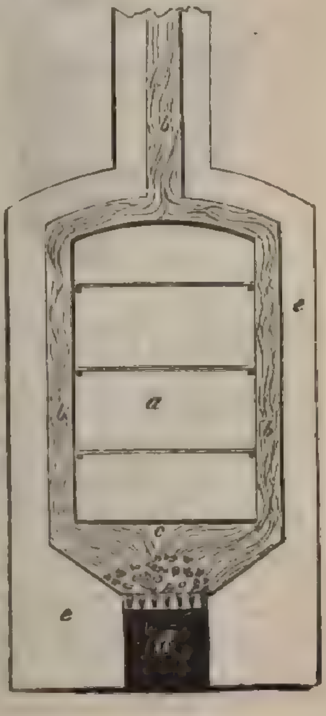
baking or drying different substances, many of which have been described in the course of this work, we shall therefore confine ourselves, in this place, to an account of that particular class of ovens which are used for the baking of bread. The common baker's oven, "upon the old principle" (as it is now distinguished), is usually a vaulted chamber of brickwork, of an oval shape, and having an iron door and frame in front; and there is mostly added in the upper part an enclosed closet with an iron grating, for the "tins" to stand on, called the proving oven. To heat these ovens, faggots are usually employed; these are put inside, and burnt to ashes, which are afterwards removed, and the bottom cleared out. During this process a great deal of the heat escapes; and as a still further length of time is required to charge the oven with the bread, the oven must necessarily be made much hotter at first than is required for the baking temperature; and, consequently, a great waste of fuel is the consequence. If the heat be not greatly in excess at first, the oven gets chilled before all the bread is put in, and causes the latter to sink and become "heavy." To remedy this inconvenience, ovens of more recent construction are built upon a solid base of brickwork, with a door of iron in front; and on one side of this is another iron door, opening into a small furnace, provided with a grating, on which the fuel (coal) is laid, and an ash-hole underneath. The fire-chamber is separated from the oven by means of a partition, but is open at the end: over this is usually erected a copper with a cock to it, for heating and supplying water to the bakehouse; and on one side of the copper is situated the proving oven, also inclosed in the brickwork. In heating the oven, the draught from the fireplace causes the flames and heated gases to sweep and reverberate around the circular walls and dome; and the soot that may be at first deposited upon the brickwork is subsequently burnt off, as the fire burns clear, or is brushed away before the bread is put in by a swab, such as is used for cleansing the decks of ships at sea. The farthest extremity of the fire-chamber is usually provided with a sliding door, by the opening or closing of which the heat may be regulated: and thus, as well as from the proximity of the fire and chamber, the heat of the oven may be kept up during the time the bread is being put in.

An oven, invented by Count Romford, and termed the perpetual oven, has been much extolled; and though we have never seen it in use, it deserves, from its originality, ingenuity, and convenience, to be better known. For the baking of small bread, pastry, and the like, its utility is manifest. The following is the description given of it by the Count, with the manner of using it:—"In the centre of a circular, or rather a cylindrical mass of brickwork, about eight feet in diameter, which occupies the middle of a large room on the ground floor, I constructed a small circular closed fireplace for burning either wood, coals, turf, or peat; the diameter of the fireplace is about 11 inches, the grate being placed about 10 inches above the floor, and the top of the fireplace contracted to about 4 inches; immediately above this narrow throat, six separate canals (each furnished with a damper, by means of which its opening can be contracted more or less, or entirely closed,) go off horizontally, by which the flame is conducted into six separate sets of flues, under six large plates of cast-iron, which formed the bottoms of six ovens on the same level, and joining each other by their sides, which are concealed in the cylindrical mass of brickwork. Each of these plates of cast-iron being in the form of an equilateral triangle, they unite in the centre of the cylindrical mass of brickwork; consequently, the two sides of each unite in a point at the bottom of it, forming an angle of sixty degrees. The flame, after circulating under the bottoms of these ovens, rises up in two canals, concealed in the front wall of each oven, and situated on the right and left of its mouth, and, after circulating again in similar flues on the upper flat surface of another triangular plate of cast-iron, which forms the top of the oven, goes off upwards, by a canal furnished with a damper into a hollow place, situated on the top of the cylindrical mass of brickwork, from which it passes off in an horizontal iron tube, about 7 inches in diameter, suspended near the ceiling of the room, into a chimney, situated on one side of the room. These six ovens, which are contiguous to each other in this mass of brickwork, are

united by their sides by walls made of tiles, about an inch and a half thick, and ten inches square, placed edgeways, having its separate canals furnished with a register communicating with the fire-place. Any one, or more of them, may be heated at the same time without heating the others; or the heat may be turned off from one of them to another, in continual succession; and, by managing matters properly, the process of baking may be uninterrupted. As soon as the meat-pies, or puddings, are drawn out of one oven, the fire may be immediately turned under it to heat it again, while that from under which the fire is taken is filled with other dishes, and closed up." We have heard of several ovens having been erected, of which this plan of Count Rumford forms the groundwork.

Hicks's economical Oven.—In the year 1830 a patent was taken out by Mr. Robert Hicks for "an economical apparatus or machine to be applied in the process of baking for the purpose of saving materials;" and for carrying this invention into effect on the great scale, the Metropolitan Bread Company (now extinct) was established. The saving of materials mentioned in the title just quoted, had reference to the saving of the vinous spirit which is generated by the fermentation of the dough, and is given off chiefly in the process of baking. This spirit, when duly rectified, is pure alcohol, and the quantity thus obtained from bread has been variously stated; but we believe it amounts to nearly a gallon per sack of flour when the oven is perfect, and the joints well luted. To make a chamber or retort so impervious as to carry on the process of distillation as well as that of baking, would, of course, be impracticable with such porous and friable materials as brick and stone; Mr. Hicks, therefore, adopted one of iron, laying inside upon the bottom a floor of bricks, that too scorching a heat might not be communicated from the metal to the bread; a fire is made under the oven, at a proper distance, and brick flues communicating with the fire chamber, are carried around the outside of the oven, so as to envelope every part. The door of the oven is made to fit it accurately by grinding, and is brought into close contact by a transverse bar and screw, in the manner of closing the mouths of retorts. In the centre of the top of the oven a large tube, or neck, is fixed vertically, extending from the brickwork which covers the iron chamber; in this tube the vapours from the bread are collected, and are thence conducted by a lateral pipe into a common distiller's worm, which, being surrounded by cold water, the vapours become condensed, and the resulting liquid, composed chiefly of water and alcohol, in the state of "low wines," is drawn off into suitable receptacles for subsequent rectification. In order to regulate the temperature of the oven, an iron tube, about the size of a musket barrel, and about a foot long, and closed at the lower end, is suspended vertically in the middle of the neck by passing it through a conical hole in the latter, to which it is closely fitted: in this tube oil is deposited, and into the oil is suspended the bulb of a thermometer, whose graduated scale above exhibits the temperature of the oil, and, consequently, very nearly that of the oven. To equalize the application of heat to the oven, Mr. Hicks adopted the revolving fireplace of Steel and Brunton. For this purpose the oven is made circular, and at about a foot from the bottom of it is a large circular plate of the same diameter as the oven (six feet), which turns in a horizontal plane on a vertical axis, forming a complete partition between the fire-place and the ash-pit, except where the fire-grate is situated, which is made of a sectorial form, and, consequently, readily admits of being shifted into or out of its place; and, in order that the air which is admitted into the ash-pit to promote the combustion of the fuel may not be diverted from its proper course, the rim of the circular plate is provided with a descending rim, which dips into an annular channel filled w water, forming what is called an hydraulic joint. Mr. Hicks states in his spe fication, that when the thermometer before-mentioned indicated a temperat of 280° Fahr., the oven is at a proper heat for baking, and that, during process, a heat from 280° to 310° should be maintained; and we know tha this temperature bread may be perfectly baked. Notwithstanding this cumstance, we have proved, experimentally, that the heat of ordin baker's ovens is usually not less than 800° Fahr. at the time the first bread

the rapidly cooling influences it is afterwards subjected to, probably h a high temperature necessary at the commencement of baking by y process; this apparently entails such a wasteful expenditure of is well deserving of investigation which of the two modes of baking, reat heat at the commencement only, or that of a moderate heat hroughout the process, is the best. It has been held, that the latter vantage of rendering the bread sweeter, by the vapour carrying off at are both unsavoury and prejudicial; while the former, from the ng *retained* in the oven, infects the bread. But this opinion can slight basis to rest upon; a little reflection will show us that in n, as in others of the same class, the vapour *must* pass off somehow, would become dense, and acquire so much expansive force, at a of 300°, as to burst open the oven. The elasticity of the vapour that of a common still, can, therefore, but little exceed the pressure sphere; but this weak steam is highly heated by radiation from the and bottom of the oven, and thus the baking is effected. Now, if we mean heat of a common baker's oven to be 450° (and we know it it is quite obvious that dense steam at a such temperature could not ructure of the kind; nor, indeed, at a heat much above 212°. And much below a baking temperature, by far the greater part of the water must escape, in the form of steam, through some chinks or fis- he brickwork or door; for if it did not, the density of the steam llibly, soon blow open the oven. The baking is, in this case, as in effected by means of weak steam, surcharged with heat, by radia- the top of the oven, which must necessarily receive a higher tempe- use it has, from its arched form, to operate at a greater distance from and has to suffer a continual without any fresh supply; s the question, whether the ric, radiating from the arched common brick oven, is greater than, that which escapes unused ous heating at a lower tempera- e are, however, other considera- h should enter into the inquiry, ave not space to pursue farther, roceed to the next subject that elf to our attention. This is a ven, which, we are informed, brought successfully into use in ilies. The annexed figure gives view, the front of the oven osed to be removed to show the nstruction. *a* is the oven; *b b* which passes over the exterior the sides, the back, and bottom ; *c* is the furnace; *d* the ash-pit; work enclosing the oven. It is d that anything should be placed tom of the oven. The shelves rmed of iron plates, but consist wo oblong trivets of wrought d side by side, a little distance each other. The oven is sup- the back by horizontal bars he brickwork at each corner. of the oven has three separate frames, one larger one for the two smaller underneath for the d the ash pit.



Notwithstanding the commendation this oven has received, it appears to us to possess the common defect of the ordinary ovens attached to kitchen grates, that of communicating a scorching heat in one part of the bread, or other article, while the opposite side of it is comparatively cold. Skilful operators may, by turning the bread frequently, and carefully regulating the temperature, bake tolerably; but without some very active circulating intermedium, ordinary attention will not suffice to bake in a proper manner. How far these defects are obviated in a recent invention, denominated Hebert's Patent Domestic Oven, the reader will determine. The object of the inventor has been to provide a very cheap and durable apparatus, capable alike of baking bread properly, and cooking other kinds of food; they are made of various sizes, to adapt them to the wants of different individuals, and are rendered as portable as possible, to suit the requirements of the army and navy. We shall here add, by way of example, a description of the smallest size, which we saw in the warehouse of the agents, Messrs. Donaldson and Glasgow, of Birmingham.

Fig. 1 exhibits an external view of the whole apparatus; the outside vessel *b* being simply a well-made cast-iron boiler, or pot, which, when used alone,

Fig. 1.

Fig. 2.

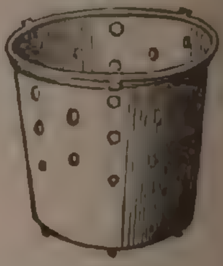


Fig. 3.

(that is, without the internal apparatus described underneath,) is applicable to all the various uses of other boilers,—but it possesses this further advantage, of having a strong double cased iron lid *c*, ground to fit so closely as to prevent the radiation of heat, and the escape of the rarefied steam, while it easily permits dense elastic vapour to pass off. The vessel is to be suspended over or in front of a fire, and in the case of the larger sizes, they may be conveniently set in brickwork, after the manner of common boilers.

For the purpose of baking bread or pastry, the roasting of meat, steaming of potatoes and other vegetables, &c., there is placed inside the pot delineated in *Fig.* 1 a perforated vessel, shown in *Fig.* 2. This vessel is made of smooth cast-iron, and drilled with holes at the side and bottom; and by means of little projecting studs, it is held steadily in the middle of the outer vessel, so as to leave a free space of about a quarter of an inch between both; around which space there is constant circulation of extremely hot vapour, which operates upon every part of the bread or other material placed therein. To receive the latter, there is a movable bottom, shown separately in the adjoining *Fig.* 3, which is removable at pleasure; but it serves to correct the tendency of too much heat in this part, when the oven is suspended over a strong fire.

it facilitates the discharge of the contents of the oven, and is easily kept perfectly clean.

Inside of *Fig.* 2 there is also placed occasionally a connected series of shelves, or pans *d d*, which may either consist of two, as represented in the annexed *Fig.* 4, or of a greater number in the larger sizes. These are for the purpose of baking small bread, rolls, biscuits, tarts, &c.—the roasting of potatoes, for frying or stewing meat, &c.—which may easily be withdrawn from the oven by means of the bail handle *e*, which is jointed so as to fall down on either side.

Fig. 4.

A fifth appendage, for roasting meat, is also supplied. It consists, as represented in *Fig.* 5, of a circular dripping pan *f*, having an upright spit *g* in the centre, and a jointed bail handle for putting it in or taking it out of the oven. The pan serves equally well for broiling, frying, and other processes, which every cook will comprehend without explanation.

Fig. 5.

The patentee states, that, by the application of the several parts of this apparatus, either in their single state, or combined in the various ways explained, bread and all other kinds of food may be *baked*, *roasted*, *boiled*, *stewed*, or *fried*, with the utmost facility and economy; the instructions for which are sent out with each of the ovens.

OXALIC ACID. This acid, which abounds in wood sorrel, and which, combined with a small portion of potash, as it exists in that plant, has been sold under the name of *salt of lemon*, to be used as a substitute for the use of that fruit, particularly for discharging ink-spots and iron-moulds, was long supposed to be analogous to that of tartar. The oxalic acid is a good test for detecting lime, which it separates from all the other acids, unless they are present in excess. It has, likewise, a greater affinity for lime than for any of the other bases, and forms with it a pulverulent insoluble salt, not decomposable except by fire, and turning syrup of violets green. Some fatal accidents have occurred from persons mistaking this salt for Epsom salts; two or three drachms of the oxalic acid acting as a violent poison.

OXIDATION. The process of converting metals or other substances into oxides, by uniting them with a certain proportion of oxygen.

OXIDES. Substances combined with oxygen without being in the state of an acid. There are several oxides of the same substances, differing in the proportion of oxygen they contain. When a substance combines with only one proportion of oxygen, it is termed the protoxide: with two proportions of oxygen, it forms the deutoxide or binoxide; with three, the tritoxide or teroxide; and with four, the peroxide.

OXYGEN, which, uncombined, is known only as a gaseous substance, was discovered by Dr. Priestley, in 1774. It has been called dephlogisticated air, empyreal air, and vital air. The term oxygen was given on the supposition that it was the sole cause of acidity. This substance is highly important in the economy of nature, as it forms about a fifth part of our atmosphere, and is abundantly contained in water, acids, salts, and oxides.

Oxygen gas may be obtained from a variety of sources. The peroxide of manganese, of lead and mercury, also nitre and chlorate of potash, yield large quantities when exposed to a red heat. The substances most commonly employed to procure it, are nitre, peroxide of manganese, and chlorate of potash. If nitrate of potash be exposed to a red heat in a coated glass or earthen retort, or in a gun barrel, a quantity of oxygen gas, (about 1200 cubic inches from a pound of nitre,) will be given off, but this is liable, particularly towards the end of the process, to be contaminated with nitrogen. From the peroxide of manganese, the gas may be obtained either by heating the substance red hot in a

gun barrel, or by putting it in the state of a fine powder into a flask, with about an equal weight of concentrated sulphuric acid, and heating the mixture by means of a lamp. In the dry way, one ounce of peroxide of manganese should yield about 128 cubic inches of oxygen. The gas procured in this way is sufficiently good for ordinary purposes, but when required of great purity, it is better obtained from chlorate of potash. For this purpose the salt is to be put into a green glass retort, and heated to redness. It first liquefies, and then on increase of heat, is wholly resolved into pure oxygen gas, which escapes with effervescence, and into a white compound called chloride of potassium, which is left in the retort.

Oxygen gas is a little heavier than atmospheric air. Its specific gravity is 1.111; one hundred cubic inches weighing 34.454 grains. It is sparingly absorbed by water, 100 cubic inches dissolving only 3 or 4 of the gas; but under great pressure it may be made to take up half its bulk. It has neither acid nor alkaline properties, for it does not change the colour of vegetable blues, nor does it evince any tendency to unite with acids or alkalies. It has neither smell nor taste. It refracts light feebly, and is a non-conductor of electricity. It is the most perfect negative electric we possess, always appearing at the positive pole when any compound containing it is submitted to galvanism. It is essential to the support of animal life: an animal will live in it a considerable time longer than in atmospheric air; but its respiration becomes hurried and laborious before the gas is consumed, and it dies, though another animal of the same kind can sustain life for a certain time in the residuary air. When suddenly compressed, it has been seen to emit light and heat, but this is said to arise from the combustion of the oil with which the tube is lubricated. It has a very powerful attraction for most simple substances, and there is not one of them with which it may not be made to combine. Any inflammable substance previously kindled and introduced into it, burns rapidly and vividly. If an iron or copper wire be introduced into a bottle of oxygen gas, with a bit of lighted touchwood or charcoal at the end, it will burn with a bright light, and throw out a number of sparks. The bottom of the bottle should be covered with sand, that the sparks may not crack it. If the wire, coiled up in a spiral, like a corkscrew, as it usually is in this experiment, be moved with a jerk at the instant a melted globule is about to fall, so as to throw it against the side of the glass, it will melt its way through in an instant, or if the jerk be less violent, lodge itself in the substance of the glass. If it be performed in a bell glass, set in a plate filled with water, the globules will frequently fuse the vitreous glazing of the plate, and unite with it so as not to be separable without detaching the glaze, though it may have passed through, perhaps, two inches of water.

All substances that are capable of burning in the open air burn with far greater brilliancy in oxygen gas. A piece of wood, on which the least spark of light is visible, bursts into flame the moment it is put into a jar of oxygen; lighted charcoal emits beautiful scintillations; and phosphorus burns with so powerful a light, that the eye cannot bear its impression. The act of combining with oxygen is called oxidation, and bodies which have united with it are said to be oxidized. The compounds so formed, are divided into acids and oxides. The former includes those compounds which possess the general properties of acids, and the latter comprehend those which not only want that character, but of which many are highly alkaline, and yield salts by uniting with acids. Oxidation is sometimes produced with great rapidity, and with evolution of heat and light. Ordinary combustion is nothing more than a rapid oxidation, and all inflammable or combustible substances derive their power of burning in the open air from their affinity for oxygen. On other occasions it takes place slowly, and without any appearance of heat and light, as is exemplified by the rusting of iron when exposed to a moist atmosphere.

OXYGENATION. Similar in meaning to oxidation, but of more general application. It signifies the uniting of oxygen to various substances, whether the result be an oxide acid, or alkali.

OXYMEL. A compound of honey and vinegar.

P.

PAINTING, House. The art of covering with various suitable pigments the wood-work, plaster walls and ceilings, iron work, &c., of the interior and exterior of houses. It may be divided into three separate branches, viz.—plain painting, graining, and ornamental painting.

The material chiefly employed in plain painting is white lead. It is a carbonate of lead produced by the action of the vapour of vinegar on sheet lead; and, when ground up with linseed oil, forms the common white lead paint of commerce. See Ceruse. It is improved by being kept for several years. To produce the different tints, various colours are added to the white lead base, in quantity according to the intensity of the tint desired, amounting, sometimes, to an exclusion of the white lead in the upper or finishing coats. The following are the colours generally used by the house painter:—

White.

White lead.
Nottingham white.
Flake white.

Black.

Ivory black.
Lamp black.
Blue black.
Patent black.

Yellows.

Chrome yellow.
King's yellow.
Naples yellow.
Yellow ochre.
Raw sienna.
Yellow lake.

Browns.

Burnt umber.
Raw umber.
Vandyke brown.
Purple brown.
Spanish brown.
York brown.

Reds.

Vermilion.
Scarlet lake.
Crimson lake.
Indian red.
Venetian red.
Red lead.
Orange lead.
Burnt ochre.
Burnt sienna.

Greens.

Brunswick green.
Emerald green.
Verdigris.

Blues.

Prussian blue.
Indigo.
Cobalt.
Ultramarine.

To bring these colours to a state fit for use, they are ground up with a small quantity of oil; but for painting in distemper, the colours must be ground up in water. Linseed oil is that which is in general use, and is quite sufficient for the purpose of the plain painter, especially when improved by being kept for several years, as it then loses a great part of its colour. It is obtained by pressure from the seed of flax. In very rare instances, where the least yellowness in the oil would be injurious, nut or poppy oil may be used with advantage.

Spirits of turpentine is largely employed in painting; it is obtained by distillation from crude turpentine, which is procured from the larch and fir-trees: being of a volatile nature, it is used by the painter to produce what is called a flat; it evaporates, and leaves the paint without the least shine. It is also employed in those situations where oil would not dry, as in the first coat on old work, which is likely to be a little greasy from smoke, &c.

To hasten the drying of paints, *dryers* are generally used. Those most in use are sugar of lead, litharge, and white copperas. These, when well ground, and

mixed in small portions with paint, very much assist them in drying; indeed, some colours will not dry without them. Red lead is also an excellent dryer; and in cases where its colour is not objectionable, is much used. Sugar of lead is, however, the best dryer, though somewhat more expensive than the others. It should be observed, that, in the finishing coats of delicate colours, dryers are generally avoided, as they have a slight tendency to injure the colour. Linseed oil has sometimes a drying quality given to it by boiling with drying substances, which renders it extremely useful on some occasions. A very good drying oil is made by boiling one gallon of linseed oil with a quarter of a pound of litharge, or red lead, reduced to a fine powder. It must be kept slightly boiling for about two hours, or until it ceases to throw up any scum; when cold, the clear oil must be poured off, and kept for use.

The tools and apparatus employed by the plain painter are not very numerous; we shall mention the principal of them. The first in order is the grindstone and muller. This is an apparatus necessary to every painter, as the purity of the colours sold ready ground at the shops is not to be depended upon; and some colours, as lakes and Prussian blue, will not keep long after grinding. The grindstone is a slab of porphyry marble or granite, about two feet square; the chief requisite is, that it be hard, and close-grained.

The muller is a hard and conical-formed stone, the diameter of the base or rubbing surface of which should be about one-sixth of that of the grindstone, and the cone high enough to get a sufficient hold of it with the hands. The face of both grindstones and muller should be perfectly flat and smooth. A large palette knife is used to gather the colour from the stone as soon as it is sufficiently ground.

The palette is a small thin board, of an oval shape, having a hole in it for the thumb to pass through; it is used chiefly in ornamental painting, and for mixing up small portions of colour on. With this is employed the palette knife, for mixing up colours on the palette: it has a long, thin, and elastic blade, rounded at the extremity.

The most important of the painter's tools are the brushes: these are of all sizes, both round and flat, and are made chiefly of hog's-hair. The large round brush called the pound brush, and a smaller one called the tool, are those mostly used in plain work. The smallest hog's-hair brushes are called fitches, and are used for putting in small work where the tool would be too large. The pound brush is used as a duster for some time previous to putting it into colour, whereby it is rendered much softer. The smallest brushes are the camel-hair pencils, with long or short hair, according to the work to be done. The variety of brushes used in graining will be spoken of when we come to that division of the subject.

The stopping-knife has a shorter blade than the palette-knife, and is pointed. It is used for making good the holes and cracks with putty.

Putty is made of common whiting, pounded fine, and well kneaded with linseed oil, till it becomes about the consistence of stiff dough.

Grinding colours.—All substances employed for painting in oil require to be ground up with a small portion of the oil previous to mixing them with the whole quantity required for use; for this purpose, they must first be pounded, and passed through a tolerably fine sieve, then mixed with a portion of linseed oil, just sufficient to saturate them; a quantity, about the size of a small egg, is to be taken on the point of the palette-knife, and placed on the stone; the muller is then placed upon it, and moved round about, or to and fro in all directions, bearing a little weight on it at the same time. This should be continued until it is ground perfectly fine, having the consistence and smoothness of butter. The colour must be occasionally trimmed from the edges of the stone and muller with the palette-knife, and put under the muller in the middle of the stone. When sufficiently ground, it is removed from the stone with the palette-knife, and a fresh quantity taken. It is not well to have much colour on the stone at one time; it makes it more laborious, and will take a longer time to grind the same quantity equally well.

Mixing colours for painting.—Before the colours which have been ground can

be applied to the work, they must be rendered fluid by the addition of linseed oil, or spirits of turpentine, or certain proportions of both. When a tinted colour is required to be mixed up, a small quantity of the proper tint should be first prepared on the palette, which will serve as a guide to mix the whole quantity by. With the ground white lead there should first be well mixed a portion of oil, and then the tinting colour should be added, as ascertained by the pattern on the palette. When these are thoroughly mixed and matched to the proper tint, the remaining portion of the oil or turpentine is to be added; this is better than putting in all the oil at once: it should then be strained through a piece of fine canvass, or a fine sieve, and should be about the consistence of cream, or just so as to work easily. If it is too thick, the work will have an uneven, cloudy appearance, and it will be hard to spread; while, if it be too thin, it will be likely to run, or will require a greater number of coats to cover the ground, and render the work solid. The straining ought not to be neglected where the appearance of the work is studied.

Preparing work for, and manner of proceeding with, the painting. New work.—Clean the work, carefully removing all projections, such as glue, or whiting spots; this is easily done with the stopping knife and duster; then cover over the knots with a composition of red lead, called knotting. The red lead has the property of drying very hard; and if it was not used, the paint would not dry on the knots, and they would show through every coat. If the knots are very bad, they must be cut out. After knotting comes the priming, or first coat of paint. When the priming is quite dry, all nail-holes, cracks, and defects, are to be made good with putty; then proceed to the next coat, called the second colour; when this is dry, those places are to be stopped which were omitted in the last coat, and proceed according to the number of coats intended to be given. It should be observed that second colour for new work is made up chiefly with oil, as it best stops the suction of the wood; but second colour for old work is made up chiefly with turpentine, because oil colour would not dry or adhere to it so well. The colour should be spread on as evenly as possible; and to effect this, as soon as the whole, or a convenient quantity, is covered, the brush should be passed over it in a direction contrary to that in which it is finally to be laid off; this is called crossing: after crossing, it should be laid off softly and carefully, in a direction contrary to the crossing, but with the grain of the wood, taking care that none of the crossed brush marks be left visible. The criterion of good workmanship is, that the paint be laid evenly, and the brush marks be not observed. In laying off, the brush should be laid into that portion of the work already done, that the joining may not be perceived. Every coat should be perfectly dry, and all dust carefully removed, before the succeeding one is laid over it.

Old work.—Carefully remove all dirt and extraneous matter with the stopping knife and duster, those places near the eye should be rubbed with pumice-stone, and greasy places should be well rubbed with turpentine. Bring forward new patches and decayed parts with a coat of priming; stop and make good with putty, then proceed with the first coat, or second colour, in turpentine. The quality of the next coat will depend upon the manner in which it is to be finished. If it is to be painted twice in oil, and flatted, the next coat, or third colour, should be mixed up chiefly in oil, and tinted like the finishing colour, to form a ground for the flatting. The greater the shine of the ground, the more dead will the finishing coat or flatting be; likewise, the more dead the ground, the better will the finishing oil shine; therefore, it is a general rule that for finishing in oil the under coat should be turpentine, and for finishing flat, the under coat, or ground colour, should be oil; but observe, that all turpentine under coats have a little oil with them, and all oil under coats, except the priming or first coat on new work, have a little turpentine with them.

Knotting is made with red lead, carefully ground, and thinned with boiled oil and a little turpentine. For inside work, red lead, carefully ground in water, and mixed up with double size, is a good substitute, and is generally used: it must be used hot.

Priming for new work.—This is made of white lead with dryers, and a little

red lead to harden it, and further to assist its drying; it is thinned entirely with oil, and should be made very thin, as the new wood, or plaster, sucks it in very fast. It is a frequent practice with painters to save the oil coats by giving the new work a coat of size, or size and water, with a little whiting, called clearcole; but where durability is consulted, this should not be done. The size stops the suction of the wood or plaster, but, at the same time, it prevents the oil paint from adhering to the work; the consequence is, that it is apt to peel or chip off, especially in damp places. Clearcole is sometimes advantageously used on old greasy work, on which oil paint would not dry.

Second colour for new work, or oil second colour.—This is white lead thinned with oil and a little turpentine, with suitable dryers. The proportion of dryers for ordinary cases is about one ounce and a half to ten pounds of white lead; but in winter, or under other unfavourable circumstances, the quantity of dryers must be increased.

Second colour for old work, or turpentine second colour.—This is white lead thinned with about three parts of turpentine, and one of oil, also a little dryers. Where much turpentine is used, less dryers is required.

Turpentine colour.—This is only used when the work is to be finished in oil; that is, left shining. It is thinned almost entirely with turpentine, that the finishing coat may have a better gloss.

Third, or ground colour, is thinned with two-thirds oil and one-third turpentine, and tinted a shade darker than the finishing colour.

Finishing oil colour is thinned with a little more oil than turpentine, and tinted to the desired colour.

Flatting, or finishing turpentine colour, is thinned entirely with turpentine, and has no shine.

A bastard flat is thinned with turpentine and a little oil, which renders it more durable than the perfect flatting. To procure a good flat, it is necessary to have a perfectly even glossy ground, and it should be of the same tint, but a little darker than the finishing flat.

For clearcole and finish.—Stop defects with putty, clearcole, and finish with oil-finishing colour, as directed.

For two coats in oil.—Turpentine second colour, and finishing oil colour.

For two coats in oil and flat.—Turpentine second colour; third colour, and flat.

For three coats in oil.—Turpentine second colour; turpentine colour; and finishing oil colour.

For three coats in oil and flat (old work).—Turpentine second colour; turpentine colour; third, or ground colour; and flatting.

For four coats in oil (new work).—Oil priming; oil second colour; turpentine colour; and oil finishing colour.

For four coats in oil and flat (new work).—Oil priming; oil second colour; turpentine colour; third or ground colour; and flatting.

TINTED COLOURS.—*Stone colour*.—White lead, with a little burnt or raw umber, and yellow ochre.

Gray stone colour.—White lead, and a little black.

Drab.—White lead, with burnt umber and a little yellow ochre for a warm tint, and with raw umber and a little black for a green tint.

Pearl colour, or pearl grey.—White lead with black, and a little Prussian blue.

Sky blue.—White lead, with Prussian blue.

French grey.—White lead, with Prussian blue, and a little lake. These last, used in various proportions, will make purples and lilacs of all shades.

Fawn colour.—White lead, with stone ochre, and a little vermilion or burnt stone ochre.

Buff.—White lead and yellow ochre.

Cream colour.—Same as the last, with more white.

Lemon colour.—White lead, with chrome yellow.

Orange colour.—Orange lead, or chrome yellow and vermilion.

Peach colour.—White lead, with either vermilion, Indian red, purple brown, or burnt stone ochre.

Gold colour.—Chrome yellow, with a little vermilion and white.

Violet colour.—White lead, with vermilion, blue and black.

Sage green.—Prussian blue, raw umber, and yellow stone ochre, with a little white, and thinned with boiled oil and a little turpentine.

Olive green.—Raw umber, with Prussian blue, thinned as before.

Pea green.—White lead, with Brunswick green, or with Prussian blue and chrome yellow.

Chocolate colour.—Spanish brown, or Venetian red and black, thinned with boiled oil and a little turpentine.

Lead colour.—White lead and black.

Plain opaque oak colour.—White lead, with yellow ochre and burnt umber.

Plain opaque mahogany colour.—Purple brown, or Venetian red, with a little black.

Black should be ground in boiled oil, and thinned with boiled oil and a little turpentine.

It will be obvious that the proportions of the colours above mentioned must be determined by the particular tone of colour required.

Distempering.—The principal difference between oil and distemper painting is, that in the latter the colours are ground in water, and diluted with size. It is much less durable than oil painting, but is cheaper, and is not attended with much smell; it will not bear washing. Ceilings are generally distempered, and walls very frequently. There are several colours used for distempering that will not do for oil, as it would change them. The principal are,—common spruce ochre, common indigo, rose pink, brown pink, blue verditer, green verditer, mineral green, and Saxon green. Whiting is the substance mostly used in distempering. It should be broken and thrown into a vessel of clean water, and left to soak for a short time without stirring it—half an hour is sufficient; the surplus water is then poured off from the top, leaving only the softened whiting, which should then be stirred, to ascertain that there be no lumps in it. To this is added hot durable size, in the proportion of one pound of size to three pounds of whiting; it is then to be well stirred, and left to chill or congeal in a cool place. In summer weather it should stand over night, when, if it is like a weak jelly, it is fit for use. If it is to be a tinted colour, the colouring substance should be added to the whiting previous to the size being mixed with it. Distemper colours dry much lighter than they appear when first laid on; consequently, it is better, before mixing the size with them, to colour a slip of paper and dry it, to ascertain if it is of the desired tint. In distempering old walls or ceilings, it is necessary that the old distemper be first washed off with an old brush and plenty of water. The holes, cracks, and damaged places, should be made good with plaster of Paris, or distemper putty, made of powdered whiting and double size. They should then have a coat of clearcole made by adding a little double size and water to the finishing colour, and using it warm. When this is dry, the finishing colour may be laid on. For new walls, it is only necessary to clearcole and finish.

Graining.—Graining comprises the imitating of woods and marbles; the latter is distinguished by the term marbling: it is strictly an imitative art, and demands in its execution considerable judgment and good taste, united to a close observation of the peculiar characters of the different woods and marbles to be represented. It is usually done on ground prepared for the purpose, the colour of which is varied according to the kind of wood or marble to be imitated; but as the manner of proceeding in imitating woods differs from that in the case of marbles, they will be noticed separately, beinning with—

Graining in imitation of woods.—The first thing to be attended to is the ground, and, although generally laid on by the plain painter, it should receive the particular attention of the grainer, for on the colour of the ground greatly depends the excellence of the imitation. The ground should be chosen of the same colour, but a little lighter, than the lightest parts of the wood to be imitated, sufficient allowance being made for the varnish afterwards to come

upon it. Repeated trials on small patterns is, however, the best, and, indeed, the only safe way of arriving at the tint proper for the ground. The ground may either be mixed up, just as in finishing-oil colour, or it may be a bastard flat; and it should be very carefully prepared, as the shine of the varnish will cause the rough or uneven places to be detected. The pigments employed for graining are distinguished by the painter as transparent colours; those mostly used are raw umber, burnt umber, raw sienna, burnt sienna, Vandyke brown, burnt ochre, and lake; these, with the occasional assistance of small portions of the opaque, or imperfectly transparent colours,—ivory black, Prussian blue, or indigo, and purple brown, or Indian red, will be sufficient to match the colour of any of the woods usually imitated. These pigments were, until within these last few years, worked in oil and spirits of turpentine; but, in consequence of the much greater facility found to be afforded by the use of water or distemper colours, oil is now seldom or never used, except for wainscot or oak graining, which is frequently done in oil. The tools employed in graining are round and flattened hog-hair brushes, of various sizes; the round ones are used chiefly for laying on the colour. Occasionally, as in very large pieces of work, large brushes of any convenient form are employed for that purpose. Of the flat brushes, there are *cutters* of various sizes, from two and a half inches to half an inch wide; these are made of camel's hair, having the ends or points of the hairs cut off square, to within about three-eighths of an inch from the ferrule; the edges should be very sharp and straight: they are used for producing the mottled appearance, as in mahogany and satin-wood. *Flat hog-hair brushes*, of various sizes, from six, or even twelve inches, to one and a half inches wide; these are used chiefly for graining wainscot in distemper. Flat hog-hair brushes, but of a much thinner description than the last-mentioned, are used for putting on the second grain, and for other purposes. *Badger-hair tools*, or *softeners*, of several sizes; this tool is one of the most necessary kind, and it is employed to soften the work put in with the other tools. *Cross-banders*, of several sizes, from one and a half inch wide and upwards; they are flat hog-hair brushes, having their ends cut off to within about an inch of the ferrule; they should be very carefully made, and of the best hair; every bristle should lay straight and even, and, when cut, should have a straight, unbroken edge, similar to the cutter. We shall describe the use of this tool when speaking of the particular woods in which it is employed. These, with camel and hog-hair pencils, sponges, and pieces of wash-leather, are sufficient to imitate any of the woods except wainscot in oil, which requires a particular tool, which will be noticed presently. The woods generally imitated are the following:—oak, (dark oak,) wainscot, or light oak, pollard oak, mahogany, rose-wood, maple-wood, satin-wood, amboyna, zebra-wood, and yew. The general instructions given for imitating these will suffice for any other fancy woods. Wainscot, or light oak, although the most common, is perhaps the most difficult to produce a good imitation of: it is done either in oil or distemper. The manner of proceeding in oil will be first described.

Wainscot in oil.—The effect of the grain in this wood is produced by the horn graining-tool, which very much resembles a comb, but the teeth are not pointed. The teeth of the graining-tool are of equal dimensions from the root to the extremity, which is square, and the interstices between them are as small as they can be cut. The principal colour used is burnt umber; this, with a little touch of black and purple brown, makes an excellent wainscot colour,—or a little raw sienna may be used with it. This colour must be tempered with a peculiar vehicle called graining oil, which is made by dissolving two ounces of bees'-wax in as much turpentine as will just cover it, and make it easy to dissolve, and by adding one pint of boiled oil, stirring it well while mixing. When it is cold it will be of the consistence of soft honey, and will, when to be used, require the addition of a little boiled oil and turpentine: a small quantity of colour is sufficient to stain a large quantity of oil. The graining colour is to be laid on very evenly and very bare. The brush marks, if not pounced out with the end of the brush or duster, must lie in the direction of the grain of the wood. The horn graining-tool is then to be passed over it, to imitate the grain; it

should be held in a slightly inclined position, and drawn along with a small waving motion, with a little pressure, passing twice over every part of the work. The veins are then to be put in, or rather wiped off, which is best done with a piece of cotton stocking, or wash leather, wrapped over the thumb nail. The veining is the most difficult part of it, and any directions that might be given, other than to observe nature closely, would be quite unavailing; nothing but a close observation of the peculiar character of the veins displayed in nature, with considerable practice, will enable any person to do it, even tolerably. As soon as it is dry, the dark shades observed in the wood are to be put in: for this purpose a little turpentine, stained with burnt umber, ground in oil, is sufficient; also the dark veins are sometimes put in with a hair pencil, and a little burnt umber and burnt ochre, diluted with turpentine. When quite dry, it may be varnished, and is then finished.

Wainscot in distemper.—Raw umber alone is a very good colour for this, or a little burnt umber may be added to it, to make a warmer tint. The fluid used for this and all other distemper graining must be such as will so bind on the colour, that the varnishing may not bring it off; small beer is the best, or, if it cannot be conveniently procured, stronger beer diluted with water may do, but there is nothing so good as stale, common table-beer. It is only necessary to mix the beer with the colour after it has been carefully ground in water, and it is then fit for use. Sometimes the colour will not lay on the ground; it is then said to *ciss*: this may be remedied by wetting the work all over with a sponge and water, and drying it with a wash-leather. Only so much should be begun at one time as can be finished before it gets dry, which it will do in a few minutes, according to the weather. The colour should be laid on as evenly and as quickly as possible, with a suitable brush, and then the flat hog's-hair brush must be drawn over it, in a straight line, and in the direction of the intended grain; this will leave it streaky: it is then to be carefully pounced or patted with the flat side of the same brush, making the head of the brush advance before the hand, and in the direction of the grain. This will make a very excellent imitation of the grain of oak, if it be well managed. The veins are to be wiped out with a piece of wet wash-leather, wrapped over the thumb nail. When this is dry, the shades may be strengthened by passing very lightly over it with weaker colour. Great care should be taken that it is quite dry before the varnish is laid on: it is not safe to varnish it in damp weather without fire being near it; but if it will bear the finger passing over it, it is dry enough.

Pollard oak.—Either burnt umber or Vandyke brown makes an excellent pollard-oak colour. The colour, in this case, unlike wainscot, should be laid on unevenly, or darker in some places than in others, after the character of the wood; a coarse sponge, moistened, and assisted by the cutter, produces the effect very well. When the masses of colour are properly disposed with the sponge and cutter, it must be softened off with the badger-hair tool, and the knots put in with the end of a hog-hair fitch, by holding the handle between the thumb and fore-finger, and twisting it round; these knots may afterwards be assisted with a camel-hair pencil. A few small veins are frequently found in pollard oak; these may be wiped off in the same manner as for wainscot. When this is dry, the second or upper grain may be put on: this grain occurs in almost all the woods except oak and rose-wood; indeed, it is the proper grain of the wood, with the above exceptions. Some of the first colour diluted will do for the second grain. To put on this grain, the thin, flat hog-hair brush should be dipped into the colour, and the hairs must be combed out to straighten and separate them. As soon as the grain is put on, the softener should be passed lightly across the grain, in one direction only; this will make one edge of the grain soft and the other sharp, as it occurs in the wood. When the second grain is dry, it may be varnished.

All the other woods are done in a similar manner. The particular character and colour of the shades and grain of the wood must be carefully noticed, and those tools which will produce the effect most conveniently must be selected; for example, the thinnest flat hog's-hair brush will best produce the effect of

the grain in rose-wood; the cutter will best produce the effect of the shades of mahogany and satin-wood; the sponge and cutter in pollard oak. The mahogany may be very well imitated by properly disposing the shades with the common round tool, with which the colour is laid on, and then passing the badger-hair softener over it in a direction across the stripes. When this is dry the second grain may be put on, as directed for pollard oak. Burnt umber and burnt sienna make a good mahogany colour.

Marbling.—Marbles are generally imitated with oil colours, and those colours are mostly opaque, as for this purpose it is not at all necessary that they be transparent. The manner of proceeding with the different marbles will not be detailed, but a few general instructions applicable to all of them will be given. The tools for imitating marble are less varied than those for imitating wood. A palette and palette knife, with numerous small sized hog-hair brushes and camel-hair pencils, and a duster, or worn badger-hair softener, are all that is necessary for imitating any of the marbles. The ground is to be chosen of that colour which is most predominant in the marble to be imitated; for example, in black and gold marble, the ground is black; in veined, it is white; in sienna, it is cream colour; and in dove marble, the ground is of a dark pearl colour. In proceeding to the imitation, the necessary colours are to be taken on the palette, and mixed up to match the tints in the marble to be imitated. In mixing, they must be slightly tempered with oil, and further tempered with turpentine for use; and they should not be laid on thicker than is necessary to produce the proper effect. The softer shades are first to be put in, blending the different colours, as may be, in the marble. As soon as they are put in a proper form, they are to be softened by brushing lightly over with a clean duster, or old badger-hair softener; but in some marbles there requires to be no softening: of course, when the shades or veins are sharp and hard, they must not be softened. The softer veins may be next put in, while the soft shades of ground-work is yet wet. As soon as this ground-work is dry, the shades may be heightened, and the strong and sharp veins put in. In putting in the soft shades or ground-work, care must be taken not to mix the colours together, so as to give the work a muddy appearance; and the colours should be used as thick as will make the work sufficiently solid, or it will look uneven when varnished.

Ornamental Painting.—This chiefly consists in painting scrolls, figures, or other enrichments on plain work, so as to give them the appearance of relief or projection; it is most commonly done in the corners and margins of panels. The ornaments or enrichments to be painted are usually sketched on paper, and the outlines are then pricked through with a needle point. This paper is to be laid on the wall or work on which the ornament is to be painted, and pounced over with a charcoal pounce-bag: the charcoal dust, passing through the small holes in the paper, will leave a faint tracing of the outline of the ornament on the work, and serves as a guide to paint it by. The brushes used are camel or sable-hair pencils, with long hair; and a rest-stick is held in the left hand, to steady the right hand by; also a palette, to work the colour from, the same as is used by artists generally. If the colour of the ornament is to differ from that of the ground on which it is painted, the pounced outline should first be filled up, and, when that is dry, the shades put in; but when the ornament is to be of the same colour as the ground, it will only be necessary to put in the shades, by the assistance of the pounced outline. As soon as the first shades are dry they may be heightened, and a stronger relief given to the ornament.

PALETTE. A small tablet, usually of ivory or wood, upon which painters lay small portions of the several pigments or tints they have occasion for in their work. Instead of a handle, it has a hole cut near the side, for the thumb of the left hand to pass through in holding it.

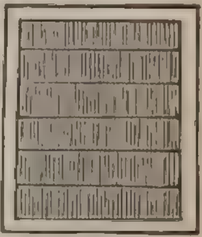
The term palette is also given by potters to the wooden instrument which they use to beat and shape out their work. Palette is a term also given to little levers employed in clock and watch work (see HOROLOGY); it is likewise applied to a variety of contrivances in mechanism, somewhat resembling in their action the little organ called by that name in the human mouth.

PALETTE KNIFE. A long knife with a very thin well-tempered steel blade, used by artists for mixing colours, or for rubbing down such as have been previously ground, on the palette. They are mounted in wood or ivory handles, according to the fancy of the user.

PALLADIUM. The name given to a metal discovered in 1803, by Sir H. Davy, associated with platina, among the grains of which he supposed the ore to exist, or an alloy of it, with irridium and osmium, scarcely distinguishable from the crude platina, though it is harder and heavier. The pure metal also very nearly resembles platina, and it takes as high a polish. It is ductile, very malleable, and, when reduced into thin plates, flexible, but not very elastic. It is harder and heavier than iron; its specific gravity is from 10.9 to 11.8.

PAPER. Thin leaves or sheets, fabricated of fibrous materials, and adapted to write or draw upon, as well as for numerous other purposes. Paper is an article of such immense importance in the commercial world, and of such general and extensive utility, that it will be well to give, in this place, a brief description of the several kinds manufactured in this country; for this purpose, we shall divide them into three classes, viz.:—Writing Papers, Printing Papers, and Wrapping or Packing Papers, with a short notice of several miscellaneous kinds, not included under either of these heads.

Writing Papers are a very numerous class, including all those that are used for writing or drawing purposes. Writing papers are called either laid or wove, according to the description of mould upon which they have been made. Laid papers are distinguished by their retaining the *wire-marks*, in long parallel lines, crossed at intervals by other stronger lines, as shown in the accompanying sketch. Wove papers, on the contrary, bear no impression of the wires, the mould used for their manufacture being made of very fine copper wire, woven in a manner similar to linen—whence the derivation of the term *wove*. Writing papers are made of two different colours, blue and yellow. The yellow cast is the natural colour of the rag, heightened as much as possible by skilful bleaching. The blue cast is obtained by adding smalt (the powder blue of commerce,) to the pulp, while in the vat. In all blue cast papers a considerable difference of colour exists between the two sides of a sheet, from the smalt, which is a heavy material, falling to the side of the sheet next to the mould: the under side, therefore, is always the bluest when the paper is finished.



Laid paper is mostly of the blue cast; wove papers are made of both kinds. Drawing papers, which are included in this class, are always made of the yellow cast, on wove moulds; and writing papers, (emphatically so called from demy upwards,) are always made of the blue cast, on laid moulds. In describing any of the numerous varieties of post, copy, foolscap, or pott papers, the distinguishing term, *laid*, *yellow-wove*, or *blue-wove*, is always necessary to be used, but in all papers from demy upwards, wove and drawing, or laid and writing, are synonymous terms; where no distinguishing term is used, laid is always understood to be meant. At the paper-mill, all kinds of paper are put up in certain parcels, called reams; a ream of paper consists of twenty quires, viz., eighteen quires of twenty-four perfect sheets, and two quires of twenty sheets each, defective paper, one of which is placed at the top, the other at the bottom of the ream, to preserve the perfect or inside paper from string-marks, and other injuries, to which, but for this precaution, it would be liable. If the two outside quires are replaced by two perfect quires, the ream is stated to be all insides, and the original value is increased five per cent. A printer's ream consists of twenty-one and a half unbroken quires, of twenty-four sheets each, and is called *a perfect ream; the perfecting*, as it is technically termed, increases the value one eighth.

The following comprehensive table gives the names, dimensions, and weight, per ream, of the several papers in this class.

Writing and Drawing Papers.

NAME.	DIMENSIONS. Inches. Inches.	WEIGHT. lbs
Antiquarian	52½ by 30½	236
Double elephant	39½ — 26½	140
Atlas	33 — 26	100
Colombier	34½ — 23	100
Elephant	28 — 23	72
Imperial	29½ — 21½	72
Super royal	27½ — 19¼	52
Royal	23½ — 19	44
Medium	22½ — 17½	34
Demy	19½ — 15½	24
Extra large thick post	22½ — 17½	25
Ditto ditto thin ditto	22½ — 17½	18
Ditto ditto bank ditto	22½ — 17½	13
Large thick post	21 — 16½	22
Ditto middle ditto	21 — 16½	19
Ditto thin ditto	21 — 16½	16
Ditto bank ditto	21 — 16½	11
Extra thick ditto	19 — 15¼	25
Thick post	19 — 15¼	20
Middle ditto	19 — 15¼	17
Thin ditto	19 — 15¼	14
Bank ditto	19 — 15¼	7
Copy	20 — 16	17
Sheet-and-half foolscap	25½ — 13¼	22
Sheet-and-third ditto	22 — 13¼	20
Extra thick foolscap	16½ — 13¼	18
Foolscap	16½ — 13¼	15
Pott	15½ — 12½	10

Drawing papers are not made smaller than demy, and are put up into reams in the flat state; writing papers, on the contrary, are not made larger than double elephant, very seldom larger than imperial, and are usually folded. The laid papers are distinguished by certain peculiar water marks; thus, post has a bugle-horn; copy, a fleur-de-lis; foolscap, a lion rampant, or Britannia; and pott paper has the English arms. By a knowledge of these marks, the original size of any paper can at once be discovered, however much it may have been subsequently reduced in size. This observation only applies to the laid papers, as in wove paper the water-mark never appears.

The post papers are seldom sold retail in the folio, *i.e.* the original size, as quoted in the foregoing list; being usually cut in half, folded, and ploughed round the edges, forming, in that state, quarto post, the letter-paper of the shops. This, cut and again folded, forms octavo post, or note-paper; another folding forms 16mo. or small note, &c., and so on to any required extent,—for this repeated folding is frequently carried so far as the production of 64mo. post, or lilliputian note paper. After the paper has been ploughed, the edges are left plain, or they may be gilt or blacked, according to fancy. When papers are folded the broadest way, they are described as broad folio; but if folded the narrow way, they are termed long folio. The other foldings are distinguished in like manner, as long or broad quarto, or octavo. These terms are mostly used in describing account-books.

Writing paper is made in all parts of England; but Maidstone, in Kent, is noted for producing the finest qualities; here all the best drawing papers are made, the celebrated manufactures of "J. Whatman," and the "Turkey Mill," being most in repute.

Printing Paper.—At the head of this extensive and highly useful class must be placed the plate papers. They are of the same size, weight, and quality as the drawing-papers, described in the foregoing list, differing from them, how-

...n being of a particularly soft and absorbent nature; the process of sizing, ...gives the firmness so necessary in papers intended to be written on, being ... omitted in manufacturing plate-paper. Plate-paper is not made smaller ...edium, which is the size necessary for the plates of a demy book. These ..., as their name implies, are used for copper-plate printing. When the ...are to be coloured, drawing-paper is usually employed, then technically ...d *hard-plate*, in contra-distinction to the former, or *soft-plate*. When ... that have been printed on *soft* paper require to be coloured, it is neces...ry to size the paper, which may very readily be done with a clear solu...of isinglass.

...taking proofs from engravings, a paper of Chinese manufacture is em...d, well known in the trade under the name of India-paper. In conse...e of its peculiarity of fibre, this paper possesses a singular degree of ...ity, which enables it to enter the finest lines of an engraving; in addition ...peculiar softness and flexibility of texture, it also appears to have an ...ent and congenial quality for fixing the ink, which causes it to take every ...and shade with much less colour and pressure, and, what is of the utmost ...tance to printers, allows the ink to set and dry in considerably less time ...any other paper. India-paper is imported in sheets, fifty-one or fifty-two ...long, by twenty-six inches wide; the weight varies; but one hundred ...usually weigh about from ten to eleven pounds.

...following is a list of the other papers in this class, the weights and sizes ...ch vary greatly, according to the choice of the manufacturer.

NAME.	DIMENSIONS. Inches. Inches.	WEIGHT. lbs. lbs.
Large news	32 by 22	32 to 37
Small news.	28 — 21	23 — 25
Royal	25 — 20	26 — 28
Medium.	23½ — 18½	24 — 26
Demy	22½ — 18	15 — 21
Short demy, for music . . .	20½ — 14	25 — 28
Copy.	20¼ — 16¼	13 — 16
Crown	20 — 15	7 — 12
Foolscap	16½ — 13¼	9 — 14
Pott	15½ — 12½	9 — 10½

...e last of these are always made in the double size. Printing-papers ...erally of a yellow-wove texture, and are not so well sized as the writing-..., but the sizing is not wholly omitted, as, without some portion of it, they ...ot possess sufficient strength for ordinary purposes.

...come now to speak of the Wrapping or *Packing-papers*. This class ...s an almost endless variety of sorts and sizes, which, for the sake of per..., we shall notice under the following heads; viz., Cartridge-papers, ...papers, Hand papers, and Brown papers.

Cartridge Papers.

NAME.		DIMENSIONS. Inches. Inches.	WEIGHT. lbs. lbs.
Square cartridge		33½ by 21½	46 to 50
Double crown	ditto	30 — 20	30 — 38
Elephant	ditto	28 — 23	48 — 52
Common size	ditto	26 — 21	40 — 50
Royal	ditto	24 — 19½	29 — 32
* Demy	ditto	22½ — 17½	26 — 28
* Foolscap	ditto	16½ — 13½	13 — 15

* These two are mostly made in the double size.

Blue Papers.

NAME.	DIMENSIONS. Inches. Inches.	WEIGHT. lbs. lbs.
Blue elephant	28 by 23	30 to 32
Ditto double crown	30 — 20	20 — 24
Ditto ditto foolscap	26½ — 16	18 — 20
Blue royal	25 — 20	20 — 22
Ditto demy.	22½ — 18	15 — 20

Hand (or white-brown) Papers.

NAME.	DIMENSIONS. Inches. Inches.	WEIGHT. lbs. lbs.
Elephant	28 by 23	30 to 36
Thick royal hand.	24½ — 20½	36 — 40
Thin ditto ditto	24 — 20	16 — 20
Royal curling.	23½ — 19½	10 — 12
Lumber hand..	22½ — 18½	13 — 15
Middle ditto	22 — 17	12 — 14
Small ditto.	20 — 15	5 — 10

Brown Papers.

NAME.	DIMENSIONS. Inches. Inches.	WEIGHT. lbs. lbs.
Imperial cap	29 by 22	50 to 84
Bag ditto	23½ — 19½	30 — 48
Kentish ditto	21 — 17½	26 — 28
Small ditto	20 — 15	10 — 12
Double four pound	32 — 20	56 — 66
Small ditto ditto	28½ — 17½	42 — 52

There are a variety of papers for particular purposes, which do not properly belong to any of the classes hitherto described; we therefore proceed to notice the principal of them, commencing with *Blotting-paper,* which must be well known to every person; it is made of three sizes, viz. medium, post, and foolscap; the weight, quality, and colour, vary greatly, but the pale red is by far the most used. Blotting-paper, especially the colourless description, is much used in chemical experiments, for the purposes of filtration; there is, however, a paper made expressly for this purpose, known by the name of filtering-paper; it is generally made the size of double crown, and is of a thick, woolly texture.

Tissue-paper is also too well known to need description, beyond stating that it is made the size of crown, double and single, and demy. A particular species of tissue-paper is manufactured and sold under the name of copying post; it is wholly destitute of size, and is of a thin absorbent texture; its size is medium; its use is for copying newly-written letters. For this purpose it is slightly moistened, and laid on the letter written with copying-ink, and then subjected to the action of a press, kept in counting-houses for that purpose; on removing the letter from the machine, an accurate fac-simile is found transferred to the copying paper, which pasted in a book, answers all the purposes of the more tedious and laborious methods of transcribing formerly practised.

Littress is a kind of smooth cartridge-paper; it is made of two sizes, royal and foolscap, and only used in the manufacture of cards. Besides many of the papers already described, grocers use a thick purple paper, which forms a distinct class, under the title of sugar blues.

Sugar Blues.

NAME.	DIMENSIONS. Inches.		Inches.	WEIGHT. lbs.
Large lump	22¼	by	32	106
Small ditto	28¾	—	21¾	102
Single loaf	26¾	—	19	80
Powder ditto.	26	—	18	58
Double ditto	22	—	15¼	44

…les the brown papers enumerated, there are some made for particular …s, among which may be noticed a large coarse paper for strong pack-…poses, known by the name of Manchester-papers: sheathing-paper, for the …hip-builders, and tip-paper for hatters, are also of a similar description. …ay be as well to observe, that although a very marked distinction has …ade in the classification of the several papers, yet such in reality does not … as the finest printing and sometimes even writing-papers are applied …pping purposes; instance the foolscaps, crowns, and demies, used by …, hatters, and the like. In hand papers, again, some difficulty occurs; …t, which stands at the head of that class, is used almost exclusively for …nufacture of paper-hangings, being joined together, and printed on: it is …f various qualities, according to the description of work for which it is …ed. The elegant crimson and satin hangings require a paper of the best … quality, which will not, therefore, properly come under the denomina-… hand-paper; but had these and similar particulars been permitted to … with the plan adopted, much unnecessary repetition and great con-… would have been the inevitable consequence. We have, therefore, given …t usual weights and sizes, which continue much the same, in whatever …e *quality* of the paper may chance to place it.

…*red papers* are of two kinds, those which are made at the paper-mill, … by colouring the pulp in the vat, by using coloured rags, or by dyeing the …fterwards; and those which are made from white papers, by persons fol-… the business of fancy stationers. In the first class, we find the coloured … or crayon papers for artists, coloured royal and demy for bookbinders, … delicate tinted post and tissue-papers, in high repute with the fair sex. …ond class comprises, in addition to some of the above, coloured double-…nd demy, for posting-bills, coloured fool-cap, (or small post,) plain and … for fancy work, and varnish coloured papers, embossed in imitation of … or figured silk, and morocco leather. To these may be added a very …riety of marble-papers for bookbinding, as also papers beautifully … in imitation of the various valuable woods and marbles.

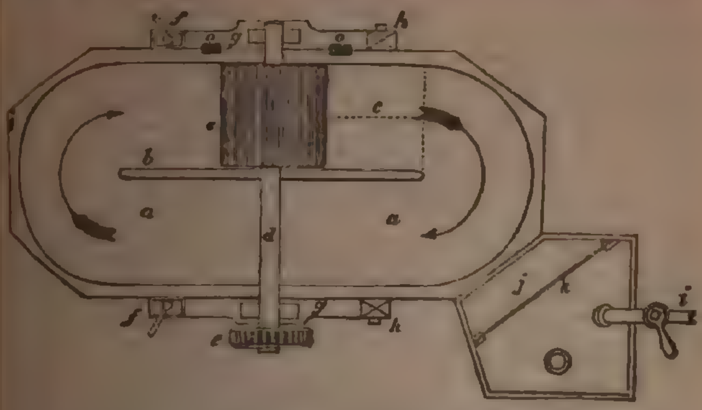
…ER MANUFACTURE. The first paper mill established in England … Dartford, by a German, (who was jeweller to Queen Elizabeth,) about … 1588. For a long period afterwards the manufacture was, however, of …or a quality as to render it necessary to have recourse to France and … for those of the better quality. The process at this time consisted in …ing the rags to fermentation, by which destructive operation they were … more easily reduced to a pulpy consistency, which was effected by … or triturating in a kind of mortar, similar to the action of the Asiatic …, described at page 201. About the middle of the last century the pro-…, by successive ameliorations, entirely changed, so as to approximate … that now used in making paper by hand. We shall therefore proceed …be, in the first place, all the ordinary manipulations practised in making … hand; and afterwards, successively, those improvements in the mecha-… which this important manufacture is now conducted.

…st kind of rags employed in the manufacture of paper are collected in …ntry, but all these are only sufficient to supply a fifth part of our …, and the inferior kinds are imported from the continent, particularly …amburgh, whence our chief supply has been drawn for many years, … being apparently the grand rag-market for the German States and … of Europe. France, Holland, and Belgium, prohibit the exportation;

a considerable quantity is, however, brought to us from Italy, and various parts of the Mediterranean. These rags are of course of every quality, from canvas to cambric, and of every tint, as respects filth or cleanliness, between white and black; those from Sicily have the hue of sepia. Notwithstanding they undergo, from their excessively filthy state, a partial cleansing before they can be shipped, they become so completely metamorphosed by the ablutions and manipulations of our paper makers, as to be converted, in a very short space of time, into a pure and spotless white paper. Before rags are brought to the mill, they are roughly sorted into several qualities, distinguished by technical terms, understood by the trade. At the mill, these sorts are more particularly sorted, according to the requirements of the manufacturer, and at the same time they are cut into pieces, if they are much larger than about the palm of the hand. A number of women are employed for this purpose, in a large room, fitted up and adapted to reduce the nuisance of the filth and dust of the operation. Each woman stands before a kind of table, formed of a wire screen, on which the rags she sorts are from time to time distributed, and moved about, which causes much of the dust and dirt to pass through the wires into receptacles beneath. At each stand there is also a fixed blade of steel, kept very sharp, over which the workwomen draw those pieces of rags that are too large, and thus quickly divide them. If the pieces be small enough, they throw them, according to their respective qualities, into one or other of a series of receptacles designed to receive the various qualities in a separate state. All the seams in the rags are carefully separated; as the sewing threads, if not thoroughly torn into filaments by the engine, would produce indentations or knots upon the paper. An active woman can cut and sort about a hundred-weight a day; the rags are next weighed, and put up into hundred-weight bags, ready for the subsequent operation. It was formerly necessary to assort the rags with great care, with respect to colour, as well as texture; but from this care they are now in a great measure relieved, by the introduction of bleaching by chlorine, which enables them to produce the whitest paper from any kind of rags: by injudicious management, however, the process is sometimes carried too far, and the tenacity of the vegetable fibre destroyed. The next operation is to boil the rags for some hours with lime, which loosens the dirt, and partially cleanses them; but this preparatory process for the operations of the mill is, we believe, confined to the most improved mills.

The paper-mill consists of a water wheel, or other first mover, connected with a combination of toothed and other wheels, so arranged as to cause the cylinder in the *washer*, and the one in the *beating* engine (which are nearly of a similar construction,) to make 150 or more revolutions per minute. On the same shaft, and of the same size as the water wheel, is a cogged wheel, which gives motion to a pinion, on whose axis is a two or three-throw crank, that works as many pumps, which raises a constant stream of water from the mill-dam; this water is kept constantly running through the rags in the washing and beating engines. The building and machinery of a paper mill should be well constructed, otherwise the great velocity of the wheels produces a tremor, which in time shakes it all to pieces. A washing engine, when it revolves at the rate of 120 revolutions per minute, and has 40 teeth, each of which passes by 14 teeth in the block, produces 67,200 cuts in a minute, and makes a most horrible growling noise; but in the beating engine, in which the cutters and teeth are smaller, and the revolution more rapid, the noise produced is one continued loud humming. The cuts made in the latter amount to nearly 200,000 per minute, which circumstance will account for the rapidity with which the rags are converted into a pulpy mass, in which the filaments are so minute as to be scarcely discernible. The washing engines of a mill are placed at a higher elevation than the beating engines, and they are actuated in the following manner. The large cogged wheel, before mentioned, drives a pinion upon a vertical axis; upon this axis are two horizontal spur-wheels, at different elevations; the upper one drives a pinion on the axis of the washing engine, and the lower one a pinion on the axis of the beating engine; and as these engines are similar in their arrangement of parts, and differ only in certain proportions, we shall make the subject intelligible by the description of one only. The figure on the next page

represents a plan of one of these engines. *a a* is a wooden vat or cistern, about 10 feet long, 4½ wide, and 2½ deep, the inside lined with lead; *b* is a longitudinal



partition, also covered with lead; *c* is a reticulated cylinder, fixed fast upon the revolving shaft *d*, extending across the engine, and put in motion through the medium of the pinion *e*, driven by a toothed wheel on the vertical shaft of the mill, as before mentioned. This cylinder is made of wood, and furnished with a number of parallel blades, fixed longitudinally around its circumference. Immediately beneath this cylinder is a block of wood extending its length, and of the breadth of the space between the two dotted lines represented. The upper surface of this block conforms to the curvature of the cylinder, and it is provided with teeth or blades, placed close together, so as to present so many acute cutting edges, which present themselves constantly to the teeth on the revolving cylinder, not in contact, but so near as to cut, chop, and tear the rags as they are forced between them by the action of the machine. The distance between these opposed series of teeth is always susceptible of regulation, by turning screws at *f f*, which raise or lower the bearings *g g* of the axis of the cylinder, which bearings are levers turning upon fulcrums at *h h*. The engine is served with water by a pipe *i* from a reservoir supplied by the pumps, which it delivers into a small cistern *j*, communicating with the engine. This pipe is provided with a cock, to stop or regulate the quantity of water; and to prevent any extraneous matter passing with the water into the engine, it has a hair or wire strainer *k* placed across it. When the engine is filled with water, and a quantity of rags put in, they are, by the revolution of the cylinder, drawn between its cutters and those on the block underneath. This cuts them into pieces; then, by the rapid motion of the cylinder, the rags and water are thrown upwards over a breasting, which rises in the same curve with the toothed block, up to about the middle of the cylinder; from this point they descend an inclined plane, whose length is represented by the dotted line *l*, and take a course round the vat, as indicated by the arrows; the whole contents of the vat are thus put in motion, which continues as long as the cylinder revolves; that being of course determined by the uniform reduction of the rags into a pulpy consistency. The cutter block is made so as to slide into or out of its place from the outside of the machine, for the convenience of sharpening its teeth, &c. The cutters of the cylinder are fixed into grooves made in the wood of the cylinder, at equal distances from each other around its circumference, in a direction parallel to its axis; the number of these grooves is twenty; and for the washer, each groove has two cutters or blades put in it; then a fillet of wood is driven fast between them, to hold them firm, and the fillets are nailed fast into the solid

wood of the cylinder. The beater is made in the same manner, except that each groove contains three bars and two fillets.

In the operation of this cylinder, it is necessary it should be inclosed in a case, or its great velocity would throw all the rags and water out of the engine. The case is a wooden box, inclosed on all sides except the bottom; one side of it rests on the edge of the vat, and the other upon the edge of the partition b. Inside this case are two hair or wire strainers, through which the foul water passes as it is dashed against them, and on the opposite side of these strainers the case is formed so as to conduct the foul water into two flat lead pipes, seen in section at o o, out of the machine. When the water is not required to be carried off, as in the beating engines, there are sliding shutters provided to these sieves, which pass through grooves on the top, and at the sides of the case, by which the water as well as the rags are returned into the engine.

When the rags have been about an hour in the first engine, if they require it, according to the modern practice, they are bleached. There are two ways of bleaching used at present; one by the oxymuriatic acid gas, the other by the acid combined in the dry way with quicklime. In the first way, the rags are boiled in an alkaline solution of potash and lime for four or five hours, or if very coarse, for eight hours. The purpose of this is to destroy the coarse part of the hemp, commonly called shon or sheave, and which exists in a great degree in coarse linens, especially German rags. The solution is then washed out in the washing engine; the water being pressed out, they are exposed to the acid in the gaseous form, as linen is; (see the article BLEACHING.) The gas is then washed out as carefully as possible; this is of great importance, as, if any acid remain in the rags, it causes the paper, after some time, to putrefy and change its colour. In the other way, the oxymuriate of lime is diffused in water by agitation, the insoluble matter is thrown out, and the liquid, when clear, is diluted and put in the engine; being thoroughly mixed with the rags, it is allowed to stand for an hour or more, and the acid carefully washed out. Bleaching is not now quite so much practised as formerly, on account of the low price of rags; indeed, we understand that unbleached papers are entirely used in the Oxford University Press, for the printing of bibles, testaments, &c., on account of their great durability. After the bleaching, (if that process is used at all,) the stuff is reduced for an hour or more in the washing engine, and is then put into the beating engine. When it has been beat, as it is called, for about three hours and a half, it is generally fine enough, and a valve placed in the bottom of the engine being opened, the stuff escapes into the chest, or general reservoir, which supplies the vat or other machinery.

We shall now proceed to describe the mode of making paper by hand, without the aid of machinery, (in the common acceptation of that term.) The vat is made of wood, and generally about five feet in diameter, and two and a half in depth. It is kept at the required temperature by means of a grate, introduced by a hole, and surrounded on the inside of the vat by a case of copper. For fuel to this grate, charcoal or wood is used; and frequently, to prevent smoke, the wall of the building comes in contact with one part of the vat, and the fire has no communication with the place where the paper is made. Every vat is furnished on the upper part with planks, inclosed inwards, and even railed in with wood, to prevent any of the stuff from running over in the operation. Across the vat is a plank, which is called the trepan, pierced with holes at one of the extremities, and resting on the planks which surround the vat. The moulds are composed of wire cloth, and a movable frame. The wire cloth is varied in proportion to the fineness of the paper, and the nature of the stuff. A laid mould consists of a frame of wood, neatly joined at the corners. Wooden bars run across it, about an inch and a half distance from each other. Across these, and consequently along the mould, the wires run, from fifteen to twenty in an inch. A strong raised wire is laid along each of the cross-bars, to which the other wires are fastened; this gives the laid wire its ribbed appearance. The water-mark is formed by sewing a raised piece of wire, in the form of letters or any device that may be wished, on the wires of the mould, which makes the paper thinner in these places. The frame-work of a wove mould is nearly the

but, instead of sewing on separate wires, the frame is covered with fine -cloth, of from 48 to 64 wires in an inch. On both moulds a deckle, or able raised edging, is used; this must fit very neatly, otherwise the edge of paper will be rough. The felts are pieces of woollen cloth, spread over sheet of paper, and upon which the sheets are laid, to detach them from form, to prevent them from adhering together, to imbibe part of the water h which the stuff is charged, and to transmit the whole of it, when placed er the action of the press. The two sides of the felt are differently raised; of which the hair is the longest is applied to the sheets which are laid n; and any alteration of this disposition would produce a change in the ure of the paper. The stuff of which the felts are made should be suf- ntly strong, in order that it may be stretched exactly in the sheets without ing into folds; and, at the same time, sufficiently pliant to yield to every ction, without injury to the wet paper. As the felts have to resist the eated efforts of the press, it appears necessary that the warp be very strong, combed wool, and well twisted. On the other hand, as they have to imbibe rtain quantity of water, and to return it, it is necessary that the woof be of ded wool, and drawn out into a slack thread. After the stuff is ready, the kman takes one of the moulds, furnished with its frame, by the middle of short sides, and fixing the frame round the wire-cloth with his thumbs, he nges it obliquely four or five inches into the vat, beginning by the long side, ich is nearest to him. After the immersion, he raises it to a level; by these vements he fetches up on the mould a sufficient quantity of stuff; and as as the mould is raised, the water escapes through the wire-cloth, and the rfluity of the stuff over the sides of the frame. The fibrous parts of the arrange themselves regularly on the wire-cloth, not only in proportion as water escapes, but also as the workman favours this effect by gently shaking mould, afterwards, having placed the mould in a piece of board, the kman takes off the frame or deckle, and glides it towards the coucher, who, ing previously laid his felt, places it with his left hand in an inclined ation, on a plank fixed in the edge of the vat, and full of holes. During this ration the workman applies his frame, and begins a second sheet. The her seizes this instant, takes with his left hand the mould, now sufficiently and laying the sheet of paper upon the felt, returns the mould, by gliding ng the trepan of the vat. They proceed in this manner, laying alternately eet and a felt till they have six quires of paper, which is called a post; and they do with such swiftness, that in many sorts of paper two men make ards of twenty posts in a day. When the last sheet of the post is covered the last felt, the workmen about the vat unite together, and submit the heap to the action of the press. They begin at first to press it with a dling lever, and afterwards with a lever of great length. After this ation another person separates the sheets of paper from the felts, laying in a heap; and several of these heaps collected together are again put r the press. The stuff which forms a sheet of paper is received, as we already said, in a form made of wire-cloth, which is more or less fine, in ortion to the stuff, surrounded with a wooden frame, and supported in middle by many cross-bars of wood. In consequence of this construction, easy to perceive that the sheet of paper will take and preserve the impres- of all the pieces which compose the form, and of the empty spaces between . The traces of the wire-cloth are evidently perceived on the side of the which was attached to the form, and on the opposite side they produce an hlage of parallel and rounded risings. As in the paper which is most finished, the regularity of these impressions is still visible, it is evident all the operations to which it is submitted have chiefly in view to soften impressions without destroying them; it is of consequence, therefore, to to the combination of labour which operates on these impressions. The er, in turning the form on the felt, flattens a little the rounded eminences are in relievo on one of the surfaces, and occasions, at the same time, llow places made by the wire-cloth to be partly filled up; meanwhile, the which is made in detaching the form produces an infinite number of

small hairs on every protuberant part of the sheet. Under the action of the press, first with the felts, and then without them, the perfecting of the grain of the paper still goes on. The vestiges of the protuberances made by the wires are altogether flattened, and, of consequence, the hollows opposite to them disappear also; but the traces formed by the interstices of the wire in consequence of their thickness, appear on both sides, and are rounded by the press. The paper, the grain of which is highly softened, is much fitter for the purposes of writing than that which is smoothed by the hammer; on the other hand, a coarse and unequal grain very much opposes the movements of the pen, as that which is beat renders them very uncertain. The art of making paper, therefore, should consist in preserving, and, at the same time, in highly softening the grain.

The exchange succeeds the operation last described; it is conducted in a hall contiguous to the vat, supplied with several presses and a long table. The workman arranges on this table the paper newly fabricated, into heaps, each heap containing eight or ten of those last under the press, kept separate by a woollen felt: the press is large enough to receive two of them at once, placed the one at the other's side, and must have a power from 70 to 100 tons. When the compression is judged to be sufficient, the heaps of paper are carried back to the table, and the whole turned, sheet by sheet, in such a manner that the surface of every sheet is exposed to a new one; and in this situation they are again brought under the press. If the stuff be fine, or the paper slender, the exchange is less frequently repeated: in this operation it is necessary to alter the situation of the heaps, with regard to one another, every time they are put under the press; and, also, as the heaps are highest toward the middle, to place small pieces of felt at the extremities, in order to bring every part of them under equal pressure. A single man, with four or five presses, may exchange all the paper produced by two vats, provided the previous pressing at the vats has been well performed. The work of the exchange generally lasts two days on a given quantity of paper. The sheds for drying the paper are contiguous to the mill; they are furnished with a vast number of cords, upon which they hang the sheets both before and after the sizing. The sheds are surrounded with movable lattices, to admit a quantity of air sufficient for drying the paper. The cords of the sheds are stretched as much as possible; and the paper, four or five sheets together, is placed on them by means of a wooden instrument in the form of a tall T. The principal difficulty in drying the paper consists in gradually admitting the external air, and in preventing the cords from imbibing moisture.

The inconvenience of the expansion and contraction of the cords from alterations in their humidity, might, we conceive, be remedied by saturating them in a solution of caoutchouc, which would not destroy their flexibility, but would enable them to resist moisture, and render their durability almost everlasting. In some mills the paper is hung upon smooth, rounded laths, and the drying is effected by steam or hot water, circulated in pipes through the room.

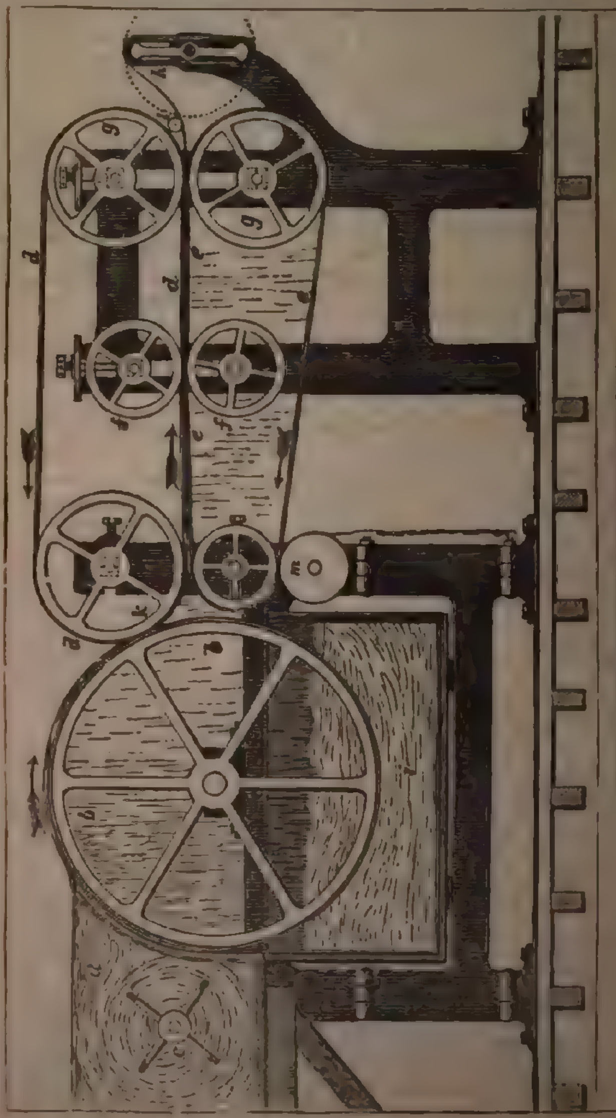
The size for the paper-makers is made of the shreds and parings procured from the tanners and parchment-makers. All the putrefied parts, and the lime, being separated from them, they are enclosed in a kind of basket, and let down by a rope and pulley into a cauldron. When the solution of the gelatin is found to be complete (which is ascertained by drawing up the basket), it is allowed to settle for a while, and then twice filtered, before it is put into the vessel into which the paper is dipped. After this a certain quantity of alum, also of smalts, or other pigments calculated to improve the tint, or bestow a peculiar hue upon the paper, is added. The workman then takes a handful of the sheets, smoothed and rendered as supple as possible, in his left hand, dips them into the vessel, and holds them separate with his right, that they may equally imbibe the size. After holding them above the vessel for a short time, he seizes on the other side with his right hand, and again dips them into the vessel. When he has ten or a dozen of these handfuls, they are submitted to the action of the press. The superfluous size is carried back to the vessel by means of a small pipe. The vessel in which the paper is sized is made of

d furnished with a grate, to give the size, when necessary, the requi- ature; and a piece of thin board, or felt, is placed between every they are laid on the table of the press. After the paper is sized it to the drying house, where a gradual drying of the sized paper is to be very important; the exchange, likewise, at this stage, requires tion, as the grain of the paper, which may then receive impressions, be restored. When the sized paper is also exchanged, it is possible wo sheets together on the cords of the drying house: the paper dries his condition, and the size is preserved without any sensible waste, e sheets of paper mutually preserve the rapid operation of the external the size has already penetrated into the paper, and is fixed on the he insensible progress of a well-conducted drying house renders all ffects more perfect in proportion as it is slowly dried. When the completed, it is carried to the finishing room, where it is pressed, nd examined; folded, made up into quires, and, finally, into reams. put twice under the press; first, when it is at its full size, and, after it is folded. The principal labour of this place consists in he paper into different lots, according to its quality or defects; after s made up into quires. The person who does this must possess great be capable of great attention, because he acts as a check on those who the paper into different lots: he takes the sheets with his right hand, , examines them, lays them over his left arm till he has the number e a quire, brings the sides parallel to each other, and places them in er the table. An expert workman, if proper care has been taken in the lots, will finish, in this manner, about 600 quires in a day. The afterwards collected into reams of 20 quires each, and, for the last under the press, where it is continued for ten or twelve hours, or as e requirements of the paper-mill will permit.

t of making paper in one continuous sheet of any required length, from an ingenious Frenchman of the name of Didot, who, in con- with the Messrs. Fourdrinier, succeeded, after the expenditure of ums of money, in perfecting this important improvement, which has great measure, superseded the desultory mode of operating we have bed. The action and arrangement of the improved mechanism may riefly explained. A horizontal frame, of any required length or furnished with a roller or cylinder at each end, over which is an endless web of brass wire, of the requisite texture or fineness, for to be manufactured by it. At one end of the frame, parallel with, diately over one of the cylinders, is a long angular trough, or sluice, the pulp is received from a vat above, wherein it is continually whence it issues through a long slit or opening, regulated by a screw, an uniformly thin stratum upon the whole breadth of the endless web which time the cylinders are in motion, carrying forward the stratum nd a joggling motion is communicated to it laterally by the alternating a rod, produced by a revolving crank; this agitation of the pulp, as drains from it through the wire-work, produces the felting, or inter- f the fibre, as perfectly as it is done by hand; and the pulp is from flowing over the sides by means of two leather straps, one on which move round with the web; and by the shifting of which straps or farther from the centre, the width of the paper may be regulated. e the pulpy mass arrives to the farthest end of the machine, it has sufficient tenacity to be taken up by a larger cylinder, covered with el, and is then passed between a series of similar cylinders, and ered on to a reel; and when this reel has sixteen or eighteen quires n it, it is removed, and another put in its place; the paper is now reel by a longitudinal incision through the coil, when it undergoes ries of operations to that we have described in making paper by full description of this machine is given in the *Repertory of Arts*, Second Series, to which we must refer our readers, in order that we room for the description of a variety of improvements in paper-

making, founded upon the admirable mechanism we have briefly notic[ed] which the public stand indebted partly to the skill, and wholly to the deter[mined] perseverance of the Messrs. Fourdrinier. It is indeed to be lamented that [these] gentlemen have never received any adequate remuneration for the benefit [which] they have conferred upon their country.

The first invention which we have to notice possesses a considerable de[gree] of novelty and ingenuity; the authors and patentees of which are M[essrs.] Dennison and Harris, paper-makers, of Leeds. The paper-mould is, i[n]



Messrs. Dennison and Harris's Patent Paper-making Machine.

...uous, but differently arranged, forming simply the exterior or peri... large drum, which revolves in the pulp vat. The preceding engraving ... elevation of the apparatus, shown partly in section. *a* is a vessel ... the pulp, considerably diluted, which is preserved at the desired ...y of the usual means, so that the pulpy liquid, when the machine is ...ll flow over the curved side of the vessel into a revolving cylindrical ... In the vessel *a*, a vane *c* is made to revolve, to keep up a powerful ...and prevent any of the fibres from subsiding. The rotatory mould *b* ... on its periphery like a sieve (which will, hereafter, be particularly ..., and, as it turns round in the direction of the arrow, the pulp is ...pon it; the chief part of the water instantly drains through the bars ...ld, and the paper, in a loose, spongy, wet state, is formed. The con...tion of the mould brings this pulpy matter in contact with an endless ...ch, by a superior attraction of cohesion, attaches to itself the pulpy ... carries it forward between that felt and another felt *e*, where it ...ressure, first from a pair of *wet rollers f f*, then a greater pressure ...*dry rollers g g*; from thence the paper, in a comparatively dry state, ...p by a rotatory vane *h*, upon which it is folded; when this vane is ...ed it is removed, and another vane substituted in its place. In this ...sheet of any required length may be made. The cylindrical mould ... in a vessel of water *i*, which serves to wash off the fibrous matter ...adhere to it, and to receive the water which drains from the diluted ...passes over. The cast-iron frame upon which the mould revolves is ...facilitate that lateral shaking or trembling motion, essential in the ... paper, which is effected by a crank and rod, or by any of the other ...s, motion being communicated from the gearing which drives the ... The roller *k* is called the *combing roller*, as it takes the paper off ... This roller is provided with a regulating screw, to tighten the web, ...e pressure against the mould. The upper wet rollers *f*, and the upper ... *g*, have also regulating screws, by which they may be elevated or ...in the long slots wherein their axes revolve, so as to increase or ...e pressure upon the wet paper. A small roller *l* is employed for ... separating the paper as it passes from the felt on to the vane *h*. As ...lt web becomes very wet by receiving the water from the paper, a ...ller *m* is employed to press out the water from it as it revolves. For ... cleansing of the webs from the fibrous matter, small rotatory ...e directed to be fixed so as to brush over their surfaces; and the ...t of jets of water to wash over the felts is also recommended by the ... As the peculiar construction of the rotatory mould forms the prin...e of this invention, and the ground of patent-right, it is proper that ...describe it more particularly. In its outline it presents precisely the ... military drum; its periphery is formed by connecting together a ...etallic rings; the cylinder is then covered longitudinally with ... small thin bars of copper, three-eighths of an inch wide, placed ..., so as to form a complete grating over the whole surface. The ...s have numerous small lateral projections, to keep them at a regular ...rt; these are directed to be made by passing plain slips of copper ...ylindrical steel rollers, with indentations on one of them, adapted for ... an uniform series of little slabs.

...been usual to distinguish laid paper (or paper made in hand moulds) ...ine paper, (or that made on the endless wire web in a machine,) by ...e water-mark lines. Hitherto the machine paper has been made on ...woven wire, which gives it that smooth, woven appearance; while the ... is marked by distinct parallel lines, crossed by a few thicker lines ...ch apart. The usual process of working wire, in making the hand ... produce the last-mentioned effect, is tedious and expensive; but ...made from them is generally preferable, and, we believe, is worth ... market.

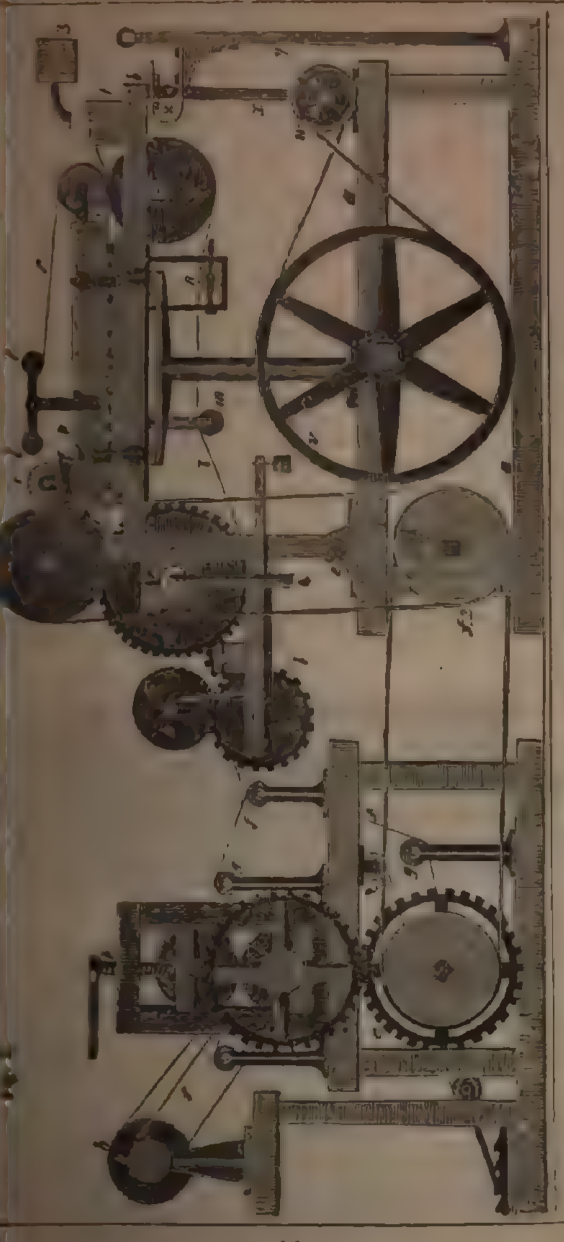
...ct of the invention we shall next describe, is to make a paper resem...hand paper, by a machine. For this purpose, Mr. Louis Aubrey, of

Two Waters, in Hertfordshire, took out a patent in 1827, for an endless web of wire that will produce the same kind of water-marks as are exhibited in the laid paper. The warp, consisting of the small wires, is put into the loom in the usual way until the reed is filled to the width required. A wooden or metal roller, about five inches in diameter, containing in a line firmly fixed as many metallic pegs as there are large water lines required in the paper: these pegs stand out from the roller about a quarter of an inch, and answer to corresponding large divisions left in the reed. The large warp is then placed on to each of these pegs, and round the roller, until a sufficient length is obtained: the ends are then passed through the front harness, placed somewhat higher than the small harness, and from thence through the large divisions in the reed, where the ends are made fast to stout iron rods. In this manner both warps are drawn tight, and the weaving is executed by the usual process. The superior thickness of the wires of the large warp causes them to project, and to produce the coarse water lines in the paper made with it.

About the same period of time, Messrs. J. and C. Phipps, of London, took out a patent for a different mode of producing the laid paper impressions in a machine, which is of easy application to a Fourdriniers' machine, as it consists simply in the addition to the latter of a revolving cylinder, which impresses the peculiar water lines required upon the wove paper as the latter is received upon the felt. For this purpose, the cylinder is formed of wooden discs at the ends, and concentric rings, and turns on a central iron axle. Over the periphery of the cylinder, the same kind of wire-work as the laid paper moulds are made of, is wound round, and carefully joined at the seam. This cylinder is mounted over the felt, so as to rest its weight upon it, by turning loosely in vertical slots, made in brass bearings on the side frames of the machine; the wire-work, therefore, passing upon the newly-made wet paper on the felt, produces the required water lines.

Mr. George Dickenson, of Buckland mill, near Dover, who has shown equal skill and perseverance in improving the mechanism of the paper manufacture, for which he has had many patents, obtained one in 1828, which, combining several previous improvements, we shall here describe. In the machines we have already noticed, it will be observed that a lateral or horizontal motion is given to the endless web of wire for felting the fibres, and separating the water from the pulp. The leading objects of this invention are to give a rapid vibration to the wire web in a vertical direction, and by rarefying the air underneath the wire web, cause the atmosphere to press upon the superior surface of the paper, by which a farther portion of the water is driven through the paper into the rarefied apartment underneath, and thus the paper is more speedily and effectually dried. From this account, somewhat of the nature of the machine may be understood. We will now describe the arrangements more particularly with reference to the accompanying engravings. The engraving on the next page exhibits side elevations of two distinct machines, which are brought into action together; they are marked *Fig.* 1, *Fig.* 2, and *Fig.* 3, which follows it, exhibits a longitudinal section of the exhausting cylinder only. In *Fig.* 1, *a a* is a wooden frame supporting the whole; *b b b* an iron frame secured to a similar one on the opposite side by a rod at top, and a bar at the end, and vibrating on a pivot *c*; *d* a cylinder, revolving on a fixed axis *e*; *f* 1 and *f* 2 band wheels, which give motion to the cylinder *d* by a toothed wheel on the axis of *f* 1, shown by dots, which takes into another toothed wheel on the cylinder *d*; *g* a cylinder revolving in pivots, supported by the frame *b b*; *h* a roller set in motion by the pinion (shown) driven by the toothed wheel on *d*, and which takes into another wheel on the end of the roller *h*; *k* another roller turning in grooves by being placed in contact with the revolving roller *h*; *l l l* an endless web of wire passing over the cylinders *d* and *g*, also betwixt the rollers *h* and *k*, and over the tightening rollers *m* and *n*, the latter of which is movable by a screw, in order to regulate the tension; *o o* a series of rollers supporting the wire web, and revolving upon spindles in notches cut in the side rails, attached to the frame *b b*; *p* a stout piece of brass called the deckle, placed on each side of the machine, over the wire web, and supported by the cross bars

be raised or lowered by screws in side pieces attached to the frame *b b* ; …le straps, revolving over pulleys attached to each end of the deckle, …milar pulleys on the axis of *f* 1, and under a pulley *s*, dipping into



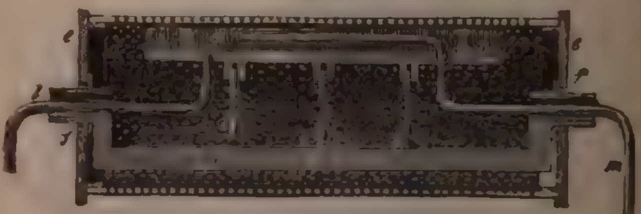
Mr. George Dickinson's Patent Paper making and cutting Machines.

a vessel of water; the straps confine the pulp at the sides of the web, and regulate the width of the paper, which is according to the distance the deckles are asunder; *t t* tightening rollers, to tighten the deckle straps; *v* a large band wheel, driven by the prime mover, and driving the smaller band wheel *w*; the latter carries a crank (not seen) set three-eighths of an inch out of the centre of the axis of the wheel, but which eccentricity can be altered at pleasure; *x* a connecting rod attached to the crank and to the frame *b*, causing the latter to rise and fall three-quarters of an inch at each revolution of the wheel *w*; *y* an iron stand, and supporting the spring *z*, upon which the frame *b* strikes at each descent of the connecting rod *x*, and thus assists the crank. 1 a pulp-box attached to the frame *b*, and extending the whole width of the wire web; to the front board is attached a piece of leather, which descends on to the wire web, and distributes the pulp equally over the web; 2 a thin piece of board, set edgeways upon the wire-web between the deckles, and keeping back the bubbles of air and water in the pulp; 3 a fixed pulp-box, which feeds the box 1, and regulates the quantity therein; 4 a pipe leading from the cylinder *d* to the air pump. *Fig.* 2, *a*, a metal roller revolving on bearings, which can be raised or lowered by the screw *b*; *c* another roller, revolving in a fixed bearing; this roller is set in motion by the toothed wheel *d* on its axis, which is driven by the wheel *e*, the latter receiving its motion from the prime mover. *f f* an endless web of felt, passing round the small rollers *g g g*, and between the rollers *a* and *c*; *h* the reel, turned by a pulley *k* on its axis; the latter is driven by a band passing over it, and a pulley on the axis of *c*.

The operation of the machine is as follows: the pulp flows from the box 3 into the box 4, thence is distributed by the leather on to the wire web; on arriving at the cylinder *d* the paper receives a considerable degree of pressure upon its external surface from the atmosphere, owing to the air being rarefied in the interior of the cylinder by means of an air pump attached to the pipe 4, and the paper is thus deprived of the principal part of its water. The continuous sheet of paper then passes between the rollers *h* and *k*, and thence on to the endless web of felt, when the remaining water it contains is pressed out by the rollers *a* and *c*, *Fig.* 2, preparatory to its being coiled upon the reel *h*.

Fig. 3, a section of the cylinder *d*. *d* is the exhausting cylinder, of brass, and pierced full of holes; *e e* end pieces bolted to *d*, and carrying toothed

Fig. 3.



wheels upon their peripheries; *f f* a hollow fixed centre, upon which *d* revolves, and bent into the form of a crank; *g* a trough composed of an iron bottom with wooden sides, and having two movable end pieces *h h*, which are set to the width of the paper, the whole is covered with leather; this trough is supported by the standards *i i i* fixed into the axis *f f*, and is pressed by spiral springs against the cylinder *d*; *l* a pipe fitted into the bottom *g*, the outer end plunged in water. *m* a pipe pierced full of holes, and leading to the air pump.

Mr. John Dickenson, of Nash Mills, Hertfordshire, to whom also the public stand indebted for several improvements in the paper manufacture, took out a patent in 1829 for "a new improvement in the method of manufacturing paper by machinery, and also a new method of cutting paper or other materials into single sheets or pieces, by means of machinery." From a perusal of the specification, we find these to consist, first, in causing the paper to be pressed betw

, the upper of which is to be heated by steam in the usual way, first side, and afterwards with the other upwards, to give it an equal gloss sides; secondly, to introduce, during the manufacture, into the centre er, threads, fine net, or other reticulated material; and thirdly, to cut heet of appropriate size, by a more convenient and expeditious method now in use. The first object he effects by carrying the paper upon a series of rollers, similar to those employed in the double machines g both sides of a sheet of paper at one time; the second, by placing ulp vessel a series of bobbins with thread, or a roller with any other o be introduced into the paper. These threads are guided, by a oller, into the pulp close to the first or feeding roller, which takes up to form the paper, and, by the current of the pulp approaching the der, the threads are brought into contact with it. The third improve- ffects by affixing to the bottom of a tall, oscillating frame, a series of volving cutters; and when this frame is made to oscillate, and the revolve, they traverse along the edge of stationary cutters, on which to be cut is extended, and thus the advantages of a clipping action

sequent patent granted to the last-mentioned Mr. John Dickenson, 1830, for an improvement upon his previously patented machinery, is to make thicker paper of a better quality than could be produced ing mechanism. To obtain this result, he employs *two* cylinders up the pulp from separate troughs at the same time, from each of b of wet paper is conveyed, by means of endless felts, to a pair of ere they are united by pressure, the subsequent manufacture of the g completed in the usual manner. To have a clear idea of this nt, it is only necessary to consider, that a duplicate of the pulp f the common machines is introduced in any convenient situation, by the localities of the mill; and that it is actuated by the same which turns the first cylinder.

month following the grant of the last-mentioned patent, another was y Mr. John Hall, jun., of Dartford, for "a machine upon a new and construction for the manufacture of paper," which we find, by a the specification, to be for precisely the same object as Mr. John 's; but the process adopted by Mr. Hall is much more elegant and In order to collect to the surface of the main cylinder of the quantity of pulp sufficient to make paper of any required thickness, employs an hydraulic pressure, in the following manner:—the made to turn in a vessel supplied with pulp on the one side, and r on the other, which rises considerably on its exterior, and through hich is made hollow for the purpose, and has a bent pipe extending the lowest part. The water is continually pumped from the interior inder; and thus, by the difference in the altitude of the water inside , an hydraulic pressure will be obtained, variable at pleasure, and is causing a greater or less quantity of pulp to adhere to the surface, overed with wire-gauze, supported by strong ribs, to admit of the the water from the exterior to the interior.

invention we have to notice is by Mr. Wilks, one of the partners of Bryan, Donkin, & Co., engineers of great experience and celebrity partment of mechanism; they having been almost unceasingly en- the construction of the Fourdrinier, and other paper machines, from st introduction to the present time: any improvement, therefore, from that house, carries with it a recommendation for utility. The nt contemplated by this patentee is the application of an additional e Fourdrinier machines. The additional roller is to be perforated, ended to facilitate the escape of the water from the pulp web, pre- its being subjected to the pressing rollers. Still more to facilitate ion of the water, Mr. Wilks proposes to employ the pressure of the , by making a vacuum within that part of the perforated roller on paper web rests. The method of making these rollers is described to

consist of the following processes: a piece of sheet copper, brass, or other suitable metal, is bent and soldered in the form of a tube, whose length is equal to the circumference of the intended roller, and whose circumference is equal to the length of the intended roller, making an allowance for the waste at the ends. The tube is then to be drawn on trebletts, in the usual manner, and afterwards turned truly cylindrical on the mandril, on which it was drawn. A series of grooves, eight or ten in number, are then turned half through the tube, with a tool the sixteenth of an inch wide, and so made as to make the bottoms of the tubes as wide as their tops. The tube is then taken from the mandril, cut open, and bent inside out, and soldered in the form of another tube, whose length shall correspond to the circumference of the first, thus constituting a hollow cylinder, with longitudinal grooves inside. It is to be again drawn, and turned with grooves to the amount of twenty-four in the inch; these will of course cross the other at right angles, and, being cut half through as before, the entire surface will be composed of transverse ridges and rectangular perforations. When it is desired to employ the exhausting principle, a second perforated cylinder is introduced within the first; the inner cylinder must be made smooth inside, that it may fit air-tight upon a sectoral cavity, extending from the axes to the circumference, enclosing about an eighth part thereof, opposite to the place covered by the web of paper, as it passes over the roller. The air is pumped from this cavity through the axis, which is made hollow for that purpose by an air-pump of the usual construction. When this method of abstracting the water is employed, the roller must be put in motion by a train of wheel-work, so arranged that it may coincide precisely with the motion through the machine.

1830. From a perusal of the specifications of patents granted about this period, it would appear, that the attention of the manufacturers of paper was rather directed to such improvements of the mechanism as were calculated to ameliorate and enhance the *quality*, than to such as might accelerate the process, and increase the *quantity*; and the ingenuity and talent thus called into action by rival manufacturers is deserving of record, were they of less practical utility. We shall therefore notice three of their inventions, in the order of the date of their patents. The first is Mr. Richard Ibotson's, of Stanwell, Middlesex.

Hitherto much difficulty has been experienced in clearing the stuff, or pulp, of which paper is made, of the small knots which are invariably found in it, and which, if not separated, necessarily deteriorate the quality of the paper. The sieves or strainers which have been generally employed for separating the knots, have been either so wide in the meshes as to permit the smaller knots to pass through, or else they very soon get clogged up; for it is evident that the fibres of which even the finest paper is made are considerably longer than one of the meshes in the sieve, and hence they will, instead of passing through, be deposited across the meshes, and immediately render the sieve useless. To remedy these imperfections, Mr. Ibotson manufactures his sieves or strainers (which he applies to the Fourdrinier machines) of metallic bars, giving the preference to gun-metal, made flat on the upper surface, and about half an inch wide, or, at all events, of a width greater than the length of any of the fibres in the pulp. The bars are strengthened by a projection extending along the middle of their lower sides, so that the cross section of one of the bars may be represented by the letter T. These bars are in a frame at a distance from each other, corresponding with the intended quality of the paper for which the sieve is to be used. He has designed, however, a very ingenious method of adjusting the distances between the bars, so as to make the same sieve answer for the manufacture of paper of different qualities: for this purpose he makes all the bars to taper uniformly, and fixes every alternate bar with its narrow end towards the same side of the sieve, and he frames the other bars together, but does not fix them to the sieve; they are introduced between the fixed bars, with their narrow ends in a contrary direction. By this arrangement, it is evident that the distances between may be diminished or increased to any degree of nicety, with the greatest facility, by pushing the frame of loose bars forwards or backwards, which is effected by means of adjusting screws. The sieve is to be placed in a

[con]veniently situated to receive the pulp from the hog, or machine by [which the r]ags are torn to pieces, and agitated into the consistence of pulp. [One end of t]he sieve, which is made in the form of a rectangular parallelogram, [is attached] by hinges to the trough, and the other is connected with a set of [levers], by which it is elevated and depressed with great rapidity; and [when the sie]ve gets clogged up by the knots, which it separates from the pulp, [it is] to be cleared by a rake or brush, made of hard bristles. This [appears] a highly ingenious invention; and, in the hands of a practical man, [c]annot fail to become useful to the public.

[A] patent, dated March 1831, is the invention of Mr. G. W. Turner, [of Berm]sey, Surrey, which consists, first, in the construction of a new species [of sieve for] separating the lumps and coarse parts of the pulp from the finer, [tha]t the latter only be employed in the fabrication of the paper; and [secondly, in] a peculiar mode of applying the sieves, so as to supersede the use of, [or t]o improved substitute for the *cat* and the *hog*. Mr. Turner describes [several form]s of sieves in his specification, slightly varied, but partaking of the [same chara]cteristic features. That to which he appears to give a preference is [of a circular] form, and consists of a series of concentric rings of thin metal, [each b]ent into a right angle, but placed with a flat side upwards, like the [letter rev]ersed, thus, Γ Γ Γ; they are arranged in concentric circles, leaving [betwee]n annular crevices about the fiftieth of an inch wide, and are [fixed b]y screws, or solder, to radial arms underneath, proceeding from a [centre] to a peripheral band, which is about 8 inches deep, and 3 feet in [diameter.] The manner in which the sieves are used we will now explain. [On the to]p of a square vat or cistern is fixed a framed standard, supporting [in plummer] blocks, at its upper extremity, the axis of a vibrating beam; to [each end o]f this beam is suspended, by a rod or spindle, one of the sieves just [so that th]e bottoms of which lie, when at rest, upon the surface of the pulp [in the vat.] The rods, or spindles, are jointed to the beam, to allow of their [acting ver]tically by its vibration, which is effected by a rod connected to a [cr]ank, the latter imparting sufficient motion to the sieves to cause [them] to be alternately lifted out of the pulp an inch or two, and then [plunged und]erneath it. To this action of the sieves is added that of a rotatory [motion, com]municated to them from the first mover by means of pulleys fixed [upon the rods] or spindles, which pass through centre holes in the standard frame, [and are prov]ided with swivel joints between the links that connect them to the [beam; each t]hus admits of a rotative as well as a vibratory action, at the same [time, which] tends to dislodge any gross particles that may stick in the inter[stices of the s]ieves, and, at the same time, to disturb and agitate the whole con[tents of the] vat. The pulp, thus reduced to a smooth and homogeneous state, [flows over a] wide lip in the vat, directly on to the endless web or mould, and [thus supersed]es the necessity of the "hog."

Mr. John Dickenson took out a patent for the same important [object,] of obtaining a perfectly uniform and smooth pulp, in order that the [paper produc]ed therefrom might be of a firm and even texture; the process we [shall now d]escribe, with reference to the figures on page 254. *a a a*, *Fig.* 1, repre[sents a sect]ion of a vat containing the pulp, which is to be regulated by a [cock; *b b*] is a false bottom; *c c* is a rotatory cylinder, through which that [portion] of the pulp that is to be made into paper passes; the knots, grit, [&c., are p]revented from entering by the wires which envelope the periphery of [the cylinde]r. These wires are arranged spirally by a continuous coil, in the [manner of a] squirrel cage, but so close together as to leave only the one hun[dred and fift]eenth part of an inch space between them. The wire recommended [for this purp]ose is to be drawn of the figure represented in *Fig.* 2, the narrow under[side of it] being fixed next to the cylinder, where it is to be fastened by rivets to [the longitudi]nal bars *e e*, leaving the uniform space between the coils as before [stated, w]hich may, of course, be easily performed by a gauge. The spaces [through wh]ich the pulp must pass are, therefore, longitudinal slits, two or [three inches] long, and only the one hundred and fifteenth part of an inch wide. [The ends of] the cylinder are closed, except at the axes of rotation, which are

formed of large tubes; through these the fine pulp received into the cylinder flows off to the mould on which the paper is formed. As there would be a continual liability of the fine interstices of the cylinders becoming clogged unless some means were adopted to prevent it, Mr. Dickenson employs what is technically termed a float (though it does not possess that precise character), which, by an up-and-down motion, agitates the liquid, and, by changing the

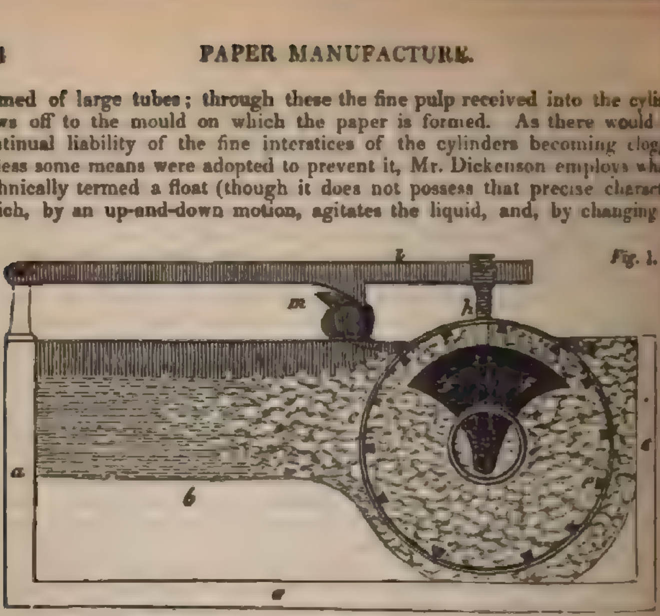


Fig. 1.

Fig. 2.

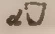


Fig. 3.

course of the current through the wires, throws off whatever has accumulated on the outside of them. This float is a close vessel of strong copper, of nearly the length of the cylinder (four feet), and of the sectional figure seen at *f f*. A horizontal bar passes throughout the lower part of this vessel, and also through the tubular axes of the cylinder, beyond the plummer boxes, in which the latter turn, where the horizontal bar is fastened to a vertical bar *h* at each end, that are connected to a lever *i*, whose fulcrum is at *k*. At *l* is a double cam, put in motion by a gear, in connexion with the wheel that actuates the rotatory cylinder; every revolution of the cam lifts the lever *i* twice by means of the wipers *m m*, and, through the medium of *h*, the copper float *f f* also, about ½ inch each time; and the "float" being somewhat heavier than the fluid in which it is immersed, falls immediately afterwards, producing the required agitation. A second improvement under this patent, consists in the knives usually employed in the transverse cutting of the endless sheets of paper; these are usually two straight-edged blades, one of which being fixed, and the proper length of paper drawn over it, the other descends and divides the sheet by a similar action to that of shears. In lieu of the upper moving knife with a straight-edge, Mr. Dickenson employs one of an angular form, represented at *n*, *Fig.* 3, which is brought into contact with the lower fixed one, shown at *o*.

A patent for "certain improvements in *sizing*, *glazing*, and *beautifying* the materials employed in the manufacture of paper, pasteboard," &c., was taken out in 18[illegible] by Messrs. De Soras and Wise; and as the process possesses novelty, and is in successful operation at the latter gentleman's mill at Maidstone, we annex the following particulars, which we have obtained by a perusal of the specification.— A ley is prepared with quicklime, the subcarbonate of soda (or potash), and water in a vessel of white wood, until the alkaline solution shall be of 104° specific gravity, water being considered as 100°. With this solution a copper is to be about one-third filled, and heat applied, either by naked fire, or by steam; but the latter is, of course, preferable. There is now to be added of white bleached wax an equal weight to that of the solution, and the whole to be stirred until a

perfect union or solution of the wax is effected: if, after a boiling of three hours, this should not appear to be the case (which will easily be discerned after a little experience, and without waiting till the materials have become cold to determine the fact), then a little more of the alkaline ley may be added, by degrees, to complete the operation: this being done, and while the solution of wax is boiling hot, there is to be added more water, in the proportion of four gallons to every pound of wax in the solution, and the boiling continued. While this is going on, the starch of potatoes, in the proportion of from four to four and a half pounds to every pound of wax employed, is to be separately mixed in a gallon of water, and thrown into the copper, which, being stirred up, the whole contents of the vessel will almost instantly assume the consistency and colour of a very fine white paste, in which state it will keep good in summer for about fifteen days. The paste, prepared as above described, is to be used in the ordinary way of sizing paper, varying the quantity with the quality of the rags operated upon. If the rags be of the coarsest kind, about 3 lbs. of the pasty solution to 120 lbs. weight of rag in the pulp will suffice; if of middling fineness, about 4 lbs.; and if the very finest rags, about 5 lbs. of the paste. Previous, however, to the mixture being made into paper, a quantity of alum in solution, equal in weight to the wax employed, is to be mixed with it. The mixture is now ready to be made into paper, either by hand or by machines, in the usual manner. After the sheets are formed, it is advisable to dry them as speedily as possible by free exposure to the air, and not to hang more than two or three sheets upon one another, which should be parted before pressing. It is also recommended, that the felts used in the subsequent pressing of the new-made paper, be wetted in a weak solution of alum, and squeezed out by the press; and that the sheets of paper be two or three times alternately pressed and parted, by which process they will acquire a beautifully firm and glossy surface. The patentees likewise direct, that the couching felts be not washed out with soap, but with the ley, whenever required. Although the weight of the potatoe flour is given in the dry state, there is no occasion to dry it (which is a tedious operation), but employ it in the moist state, in which it deposits itself at the bottom of the vessels. Potatoe flour, in drying, loses 30 per cent. of water; which weight of water should be deducted in calculating the weight of flour employed. As several kinds of paper require only small quantities of sizing materials, those points must be regulated by the knowledge of the manufacturer.

The manufacture of stout and beautiful drawing-boards has occupied the especial attention of Mr. Steart, of De Montalt paper-mills, Coomb Down, near Bath, who received an honorary medal from the Society of Arts, Manufactures, and Commerce, for the communication of his process, which we have abridged as follows, from the *Transactions of the Society*.—The extra stout drawing papers, or card boards, as they are usually denominated, are always made by pasting several sheets of paper together in the manner of a common pasteboard, and afterwards bringing them to a smooth face, by pressing and rolling. The pasting is a dirty operation, and the occasion of many defects, some of which are fatal to the degrees of perfection and nicety required in a good drawing board. Another great defect is, that the far greater part of the drawing and writing papers now in use in this country, are of a hollow or spongy texture; this arises from their being made of an indiscriminate mixture of linen and cotton, the greater elasticity of the latter preventing its fibres from closely uniting with those of the wax; the consequence is, an irregular surface, and a porous, spongy substance, very different from that which an adherence to the good old-fashioned practice, of using fine linen rags only in the manufacture of superior papers, would produce. The lino-stereo tablet is entirely free from these objections for the following reasons:—first, it is not composed of several sheets pasted together, but is moulded from the pulp of any required thickness, in one entire mass; thus the risk of pasting is avoided, and no separation of the component parts can possibly take place, though wetted ever so often; secondly, instead of being composed of linen and cotton, it is wholly and solely manufactured from the best and purest white linen rags, most carefully selected, and,

consequently, without the aid of chloride of lime, or any bleaching pro whatever.

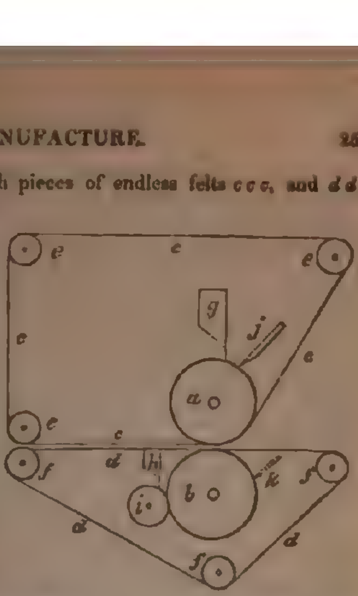
The process.—In selecting the raw materials for the manufacture of lino-tablets, great care is taken to preserve the best and purest white linen r only, rejecting all muslins, calicoes, and every other article made of cott The linen rags are then carefully sorted, overlooked and cleaned, washed, beaten into pulp, in the usual manner practised by paper-makers of the f class. The pulp being ready, and diluted in the vat with the proper proporti of pure water, the workman, dipping his mould first into the vat, takes it filled with pulp to the top of the deckle, and holding it horizontally, and gen shaking it, causes the water to subside, leaving the pulp very evenly set upon t face of the mould; having rested it for a moment or two upon the bridge of t vat, the compresser, with its face downwards, is now carefully laid upon the she or tablet, and both together placed in the small press close at hand, where it submitted to a very gentle pressure, in order to exclude a great proportion the water remaining in the sheet; it is then withdrawn; the compresser and t deckle are then both taken off, and another workman couches it by very de terously turning the mould upside down, and pressing it pretty hard with h hands on one of the fine felts previously laid upon a very level pressing plan by which means the tablet is left on the felt. The mould is then returned the vat-man, who repeats the process as before: the coucher, in the mean tim lays another felt upon the sheet or tablet just couched, whereon the seco sheet is to be laid in the same manner, and so on until all the felts are occ pied; over which another level plank is placed, and the whole drawn away a small rail-road waggon to the great press, where it undergoes a pretty seve pressure.

The tablets will now be found to have sufficient adhesion to bear handli with care, and are separated from the felts, and placed one upon another, so to form the packs; these packs are to be submitted again to the action of t press, until more water is expelled; then are parted sheet by sheet, pressed parted again; and this is repeated as often as is necessary, taking care increase the pressure every operation, until the face of the tablets is sufficien smooth; they are then carefully dried, sized, picked, sorted, &c.; carried the rolling mill, and several times passed between the polished cylinders, to g them the last finish.

The above is the process for the plain or white tablets. In making tinted tablets, the following additional particulars are to be attended to. The r are cleansed, washed, and beaten into half stuff, in the usual way; the wa being drained off, the pulp is put into a vat with a solution in water of ace of alumine, or sulphate of iron, as a mordant or ground to fix the colour inten to be made; the whole is well incorporated, and suffered to remain for half hour or more, when the colouring tincture, previously prepared, is added; which, the whole being returned to the engines, is beaten into fine pulp, then wrought into fine tablets. The dyeing materials chiefly made use of Mr. Steart, are, mangrove bark, quercitron bark, best blue Aleppo galls, sulph of iron, and acetate of alumine. A due combination of these materials p duce a great variety of drabs, greys, sand-colours, &c.

An apparatus and process for sizing paper in a more effectual manner t it had previously been done, was recently patented by Mr. Towgood, of D ford, in conjunction with Mr. L. Smith, of Paternoster-row, London. T invention consists in the application of *pressure* along with the size; which effected by depositing on the surface of a pair of pressure rollers, or on one them, if the paper be required to be sized only on one side, a thin uniform of size, which is pressed into the paper as it passes between the rollers. endless felt is sometimes made to pass over each of the rollers, and in that the size will be forced through the felt to the paper. This sizing appara may be applied either separately, or in combination with a paper machine any construction; but the form and arrangement of the different applicati will necessarily vary with the form of the machinery to which it is appl The form represented in the following diagram will be sufficiently explanat

a b represent two pressure rollers, with pieces of endless felts *c c c*, and *d d d* passing around them, being supported and guided by a series of friction rollers *e e e* and *f f f*; *g* is a small trough with a perforated bottom for supplying the surface on the surface of the pressure roller *a*; and *h* is a similar trough for supplying size to the roller *i*, which transfers its supply to the other pressure roller *b*; and *j j* are two scrapers for keeping clean the surfaces of the pressure rollers.



The cutting of paper into sheets of any required dimensions as exactly and expeditiously as possible, is an object of great importance to the manufacturer; and as the machine-made paper is of considerable greater width than is required, it becomes necessary to cut it lengthwise. The following is the patented method adopted by Mr. Crompton, of Tamworth, in Lancashire, and Mr. Taylor, of Marsden, in Yorkshire, according to their enrolled specification, dated 1828. *Fig.* 1 is a side elevation of the machine; *Fig.* 2 a plan of the cutters. *a* is the roller upon which the paper (either in the moist state in which it is delivered from the felts when freshly made, or when dry,) is rolled; *b b* and *c c* are two pairs of drawing rollers, which conduct the paper first between the circular cutters

Fig. 2.

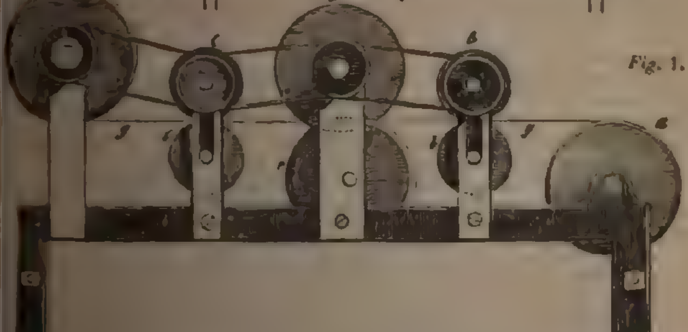


Fig. 1.

e e, and thence on to the roller *d*, where it is wound in its divided state. The shaft upon which the upper cutter is fixed, is driven by any prime mover; and by means of endless bands and pulleys it imparts motion to the upper drawing rollers *b* and *c*: these two upper rollers turn the two lower, by means of cog-wheels at the other extremities of their axes, which gear into each other; the

upper cutter has in like manner a toothed wheel upon its axis, which tur another toothed wheel upon the axis of the lower; none of these toothe wheels are brought into view in the drawing, to prevent confusion. By th revolutions of these parts of the apparatus, the paper, represented by a line *g g* is drawn from *a* between the rollers *b*, is severed at *e*, and thence is carried by the rollers *c* on to *d*, by means of an endless band from the latter, as shown In order to accommodate this movement to the increasing circumference of the roller *d*, occasioned by the paper accumulating upon it, the band pulley on *d* is a friction roller, which is set so as to allow of its slipping a little in its revolutions. It should also be noticed, that the axis of the lower cutter is not quite parallel to the axis of the upper one, by which means the edges of the cutters facing the rollers *a* are brought into contact, whilst the other edges diverge, which causes the paper to be more freely delivered from the cutters. The great rapidity of this process of cutting is evident.

Another method of cutting paper of great merit was patented by Mr. Edward Newman Fourdrinier, paper maker, of Hanley, in Staffordshire. It consists of a series of receiving rollers placed one over the other. The several webs of paper to be cut pass over these, are then brought together, and passed over the collecting roller equally distant from the others; and thence, by the aid of an endless felt or blanket which passes about a series of guide rollers, they are conveyed under the main cylinder of the machine, and delivered to the cutter at the opposite side to which they entered. The cutter consists of a machine which acts on the principle of shears; the lower blade being fixed, and the upper attached to an arm which vibrates upon a centre, and placed to meet the stationary blade at an appropriate angle, so as to produce the best clipping action. When a sufficient quantity of the paper has passed over the lower blade to constitute the length of a sheet, the upper blade begins to descend; but previously to the blades coming into contact, a holder, consisting of a bar extending the whole width of the paper connected with the same vibrating arm, is made to press down and hold the paper firm on the lower blade, while the cutting is performed. During the operation of cutting, the main cylinder, as well as the guide rollers, remain stationary, while an actuating rod returns to bring another length of paper. This vibrating rod gives motion to a sector which has on its upper side ratched teeth, that are acted upon by the rod as i moves in the direction from right to left, but which remain stationary whil the rod moves in the contrary direction. The sizes of the sheets cut by thi machine are regulated by an expanding crank, which gives motion to th actuating rod, and through that means to the main cylinder, and other parts o the apparatus.

A great many materials as substitutes for rags in the manufacture of pape have been at different times proposed; the bark of the willow, beech, hawthorn and lime, the stalks of the nettle and thistle, the bine of hops, indeed almost ever vegetable substance capable of yielding easily an abundance of strong fibre, hav been suggested, and excellent paper has been made from some of them; bu the introduction of the bleaching process, and the improvements made in th mechanism for forming the pulp, having enabled the coarsest linen and cotto fabrics to be brought into use, the supply of rags is at present found equal t the demand for paper, immense as that is. The rapidly increasing knowledg of the people in most parts of the world will probably create an increased deman for books, and the stock of rags may again become inadequate to supply th paper manufacturer, who must again have recourse to other materials: we pro pose therefore to describe three patented processes for this purpose; namely one for making it of *straw*, another for the employment of *moss*, and a third fo the use of *solid wood*.

Mr. Lambert's process for making paper of straw is as follows:—Havin collected a quantity of straw, all the joints or knots are to be cut away, an the remainder boiled with quicklime in water, for separating the fibres, an extracting the mucilage and colouring matters. (Instead of quicklime in thi part of the process, caustic, potash, soda, or ammonia, may be employed.). I is then to be washed in clear water to get rid of the colouring matter and lim

wards subjected to the action of an hydro-sulphuret, composed of one quicklime, and a quarter of a pound of sulphur to every gallon of the more effectual removing of the mucilaginous and silicious matters. the material is to undergo several successive washings in different get rid of the alkaline and other extraneous matters, which may be ly effected by beating in the ordinary paper-mill. When no smell is left, the water is to be squeezed from the fibrous material by pressure, and then to be bleached by chlorine, by exposure on a or any other convenient and well-known means; it is then to be ain, to get rid of the bleaching ingredients, next to be reduced to he common apparatus for the purpose in a paper mill, and then nto sheets. The subsequent operations are, in other respects, similar made from the usual substances.

aper.—Mr. Nesbit, of Upper Thames-street, had a patent in 1823 rication of a coarse kind of paper, especially applicable to the sheath- in the manner that the tarred brown paper is usually applied. The a peculiarly soft kind of moss, which grows abundantly in the ditches ounds of Holland. In that country, and in several of the northern ermany, paper made from this material is employed as a covering to s of ships, between the wood and copper sheathing, and is found to y serviceable in preventing leaks; owing to its absorbent quality it making a close and firm packing under the copper. The manufac- per from this substance is exceedingly simple. The moss is first to thering earth washed from it, then to be chopped in short pieces an inch long) in a similar machine to a tobacco cutting-mill; after be soaked for several hours in water, then formed into sheets in the ay between moulds, placing each sheet between woollen cloths; in ey are to be subjected to mechanical pressure, afterwards thoroughly lastly, pressed again between sheets of brown paper, (placed alter- en the manufacture is completed.

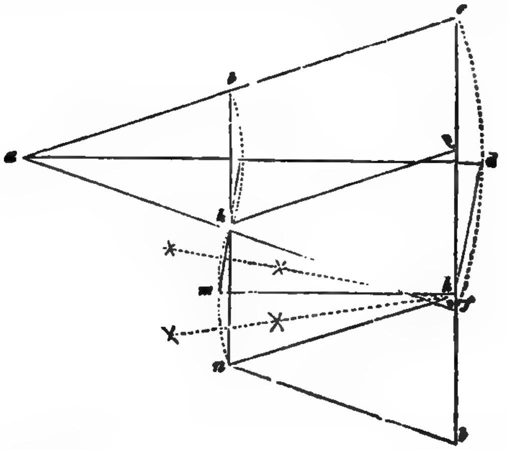
rom Wood.—This process is the subject of a patent lately granted in States. The shavings of wood are to be boiled in water, with from 12 by weight, of common alkali, which reduces the wood to a mass of ted for conversion into paper by the ordinary means. One hundred wood, the patentees state, will make from five to seven reams of paper. per is described under the word IVORY. Paper hangings being made paper, subsequently stained or printed, are noticed under the head

R-MACHE. A name given by the French to an artificial substance, many useful and elegant purposes. It is made of the waste cuttings boiled in water, and beaten to a pulp in a mortar. It is afterwards size to give tenacity to the paste and when brought to the proper it is pressed in moulds of an infinite variety of forms; and thus ea-boards, trays, snuff-boxes, &c., which are afterwards coated with varnished and ornamented.

RANDINE. A new invention, the object of which is to avert hail- ing in the same manner as the electric conductors for obviating lightning. In this climate the hail is seldom so violent as to occasion rious losses; but in many parts of the continent it is dreaded as the uctive enemy of the husbandman, and has given rise to the establish- urance companies, to compensate the sufferers. The inventor of the e is a Signor Apostolla. One of the latest accounts of its beneficial published by Antonio Perotti, who states, that having, on a piece of ing to himself, containing 16,000 perches in extent, fixed up several of ndines, he had the satisfaction to find that no injury was done by hail and very little to the vines, although no less than fourteen storms had the current year, five of which appeared to threaten great mischief but passed over them, and fell on the neighbouring lands. These are composed of metallic points and straw ropes, bound together or flaxen threads. Dr. Astolfi relates that in a hail-storm the

clouds were seen to disperse on passing over lands protected by paragrandines. A notice contained in an official report to the Milan government by the Gonfalonieve of St. Pietro, in Casale, also states, that during a stormy day, when there were many claps of thunder and flashes of lightning, he went out to observe the effects of the paragrandine, and noticed that the electric fluid was attracted by the points of straw in the apparatus, around which the flame played in graceful curves; while in the adjoining field, not protected by the paragrandine, much rain fell, and the lightning did considerable mischief. We have thought it proper to introduce this notice of a foreign invention, as it appears to be capable of beneficial application in this country in the protection of agricultural produce collected in stack-yards.

PARALLEL MOTION. A term applied by practical machinists to an arrangement of parallel bars, by which the alternating rectilinear motion of a piston rod is made to work harmoniously with the alternating curvilinear motion of a rocking beam. As the beam of all engines vibrates upon a centre, of course it performs portions of a circle with each of its extremities; and as the rod of a piston is required to move up and down in a straight line, it cannot be immediately attached to the end of the beam; hence the necessity of the intervening mechanism called the parallel motion. There are many methods of effecting this motion in general use; and ingenuity may devise many more of equal or superior merit. In single engines of the old construction, where the action was a *pull* at both ends of the beam (at the one end by the weight of the pump rod, and, at the other, by the downstroke of the piston), a chain was affixed to the upper part of the curved ends of the beam, and to the pump and piston rods, which answered the purpose very well, and is still much used for similar purposes; but in double acting engines, where the piston rod *pushes* upward, as well as *pulls* downward, some other mode of action is required. The first plan employed by Bolton and Watt was to place a toothed sector on the end of the beam, the length of the radius being equal to the distance between the axis of the beam, and a vertical line passing through the centre of the piston rod; and on the upper part of the piston rod was placed a rack, which acted upon the sector, and forming a tangent to it, preserved the rectilinear motion of the piston rod throughout the stroke. A much superior method of effecting this was afterwards devised, to which the name of parallel motion more justly belongs; it consisted of an arrangement of parallel rods moving on circular axes, the principle of which may be thus briefly explained:—If a bar be so confined by other bars that the motion of the end *a*, in a right line, causes the



other end *b* to describe a certain curve, it follows, on the other hand, the motion of *b* in the curve will cause *a* to describe a right line. To apply this to the case

before us, let *a b c* represent the beam of an engine at the highest point of the stroke; *a d* its position at the middle of the stroke; and *a f* its lowest position: *c g* and *b h* are two side rods, suspending the bar *g h*, parallel to *a b c*; *g k l* a right line, in which the bar *g* moves in a groove; then, when the end of the beam *c* is at *d*, the end *g* of the bar *g h* will be at *k*; and as *g h* is parallel to *a d*, the other end *h* of the bar *g h* will be at *m*; and when *c* arrives at *f*, *g* will be at *l*, and *h* at *n*; the point *h*, therefore, will have described a curve, in a right line, passed through the points *g k l*; if, therefore, the groove in which the head of the piston-rod moved be taken away, and the end *h* of the bar *g h* be jointed to a radius bar, describing a circular arc passing through the points *h m n*, then the end *g*, of *g h*, to which the piston rod is attached, will move through the points *g k l*, and the whole path of the piston rod will differ very little from a right line. The small deviation from a right line arises from the circumstance, that the curve described by the end *h* is not exactly a circular arc when *g* moves in a strictly right line. To find the length and centre of motion of the radius bar with any distance in the compasses, and on the points *h m n*, describe arcs intersecting each other; and through the points of intersection draw lines cutting in *o*; then *o n* will be the length of the radius bar, and *o* its centre of motion.

The parallel motion in general use in steam-boats is represented in the foregoing diagram. The length of the radius bar and the centre of motion may easily be found, as in the former case, by supposing the piston rod to move in a right line, and finding three points, through which a point in the side rod (assumed at pleasure) would pass in the highest, lowest, and middle position of the piston rod; then a circle, which passes through these points, will give the radius and centre sought; and the point assumed in the side bar will be the point for its connexion with the radius bar. *a b c*, part of the beam; *c g* and *b h* side rods; *g* the point of junction of the piston to the side rod *c g*; and *m o* the radius bar.

In portable engines without a beam, the cross on the head of the piston rod has usually on its ends friction wheels running between guides; but we prefer the parallel motion introduced in Lloyd's portable engine, described hereafter, as it affords a convenient method of working the air pump and cold water pump. The principle of the parallel motion in this engine will be understood by reference to the following diagram. *a b c* represent a bar corresponding to half the beam of an engine, *c k f* the path of the piston rod, and *b k* the radius rod; now the radius rod, and the two portions of the beam *a b*, and *b c* being respectively equal, if *a* move in a right line towards *g*, *c* will move in the line *c k*, and if *a* be connected to a rocking bar *a e*, which, from its length, or its small angular motion, describes an arc *g a*, differing but little from a right

line; and a side bar or strap *b h*, and the parallel bar *h e* being added, the centre of *b h* will be the point of suspension for the rod of the air pump, and the rod of the cold water pump may be suspended from the parallel bar *h e*.

PARALLELOGRAM OF FORCES. A term used to denote the composition of forces, or the finding of a single force that shall be equivalent to two or more given forces when acting in given directions.

PARALLEL RULER. An instrument for drawing lines parallel to each other. The simplest parallel ruler is the common cylindrical ruler of the counting-house, represented at *Fig.* 1; it serves very well for common purposes, where great exactness is not required. *Fig.* 2 is the common parallel ruler, consisting of two flat rulers connected together by two small brass levers jointed at their extremities; the mode of using this instrument is too obvious and too well known to need explanation. An objection to the latter, of the bar moving circularly sideways, is obviated in the instrument represented at *Fig.* 3; the bars in these being crossed and connected at the point of intersection by a joint, and two of the ends sliding in grooves, as seen at *b b*, causes the rulers to move uniformly straight, or at right angles with their length. *Fig.* 4 exhibits another arrangement in use, whereby a similar rectilinear motion is produced by two pair of short bars, connected to an intermediate slip *c*, which, when the ruler is closed up, exactly fill up the cavity between the pieces on either side. *Fig.* 5 represents another parallel ruler of great convenience and utility. It is usually made of black ebony, with slips of ivory at the edges, divided into inches and parts; a hole is cut through the ruler at *e e*, in which revolve two little brass wheels, projecting about an eighth of an inch from the under surface, and upon which the ruler is rolled, steadily held in the middle by the left hand, whilst the draughtsman draws the lines with his right. The brass wheels are fixed to a steel spindle, which turns in brass bearings at its extremities; between each bearing and brass wheel there is a little ivory cylinder, divided into equal parts, which revolves with the latter, and shows precisely the quantity of motion in the ruler, and thus enables the draughtsman to draw his lines at equal or any desired varying distances apart. The steel spindles in the more recently constructed rulers are cased over with ebony, which renders them more convenient as well as more durable.

1.

2.

3.

4.

5.

PARBUCKLE. A term given to a contrivance whereby a cask, &c. is

...ed or lowered without a crane or pulley tackle; it is formed by passing the ...le of a rope round a post or ring, or under a boat's thwart; the two parts ... the rope are then passed under the two quarters of the cask, bringing the ... ends back again over it, which, being both hauled or slackened together, ... raise or lower the barrel, &c., as may be required.

PARCHMENT. A durable material, prepared from the skins of sheep and ...s, but chiefly the former, and employed for writing upon, the covers of ...ks and various other purposes. The skin is stripped of its wool, and passed ...ugh the lime-pit. The skinner then stretches it on a frame, perforated lon...inally with holes furnished with wooden pins, that may be turned at plea..., like those of a violin, to stretch the skin like a drum-head. The skin being ... sufficiently stretched on the frame, the flesh is pared off with a sharp instru...t; it is then moistened with a rag, and white chalk, reduced to a fine dust, ...ed over it; then, with a large pumice-stone, the workman rubs over the ..., and thus scours off the remains of the flesh. They then go over it again ... an iron instrument, moisten it as before, and rub underneath with pumice...e, without any chalk; this smooths and softens the flesh side very con...ably. They drain it again by passing over it the iron instrument as ...re. The flesh side thus drained, they pass the iron on the hair side, then ...ch it tight on the frame by means of the pins, and go over the flesh side ... with the iron; this finishes its draining: the more the skin is drained the ...er it becomes. They now throw on more chalk, sweeping it over with a ... of lamb-skin that has the wool on; this smooths it further. When dried ... taken off the frame by cutting all round. The skin thus far prepared by ...kinner, is taken by the parchment-maker, who first scrapes or pares it dry ... summer (which is a calf-skin stretched in a frame) with an iron instru...t like that above mentioned, only finer and sharper; with this, worked with ... from the top to the bottom of the skin, he takes away one-half of its ...; and the skin thus equally pared on both sides, is rubbed with the ...-stone to smooth it. This last preparation is performed on a bench, ...ed with a sack stuffed with flocks, and it leaves the parchment fit for ... upon. Vellum made from the skin of sucking-calves possesses a finer ... than parchment, but prepared in the same manner without being passed ... lime water.

PARTING, in Metallurgy, is an operation by which gold and silver are sepa...d from each other. In this sense it is the same with refining metals, or obtain... them in a pure state. Gold and silver are called perfect metals, because ... capable of withstanding the action of very strong heat. All other metals ...duced to the state of oxides when subject to fire with access of air. Gold ... may, therefore, be purified from baser metals by keeping them melted ... alloy be destroyed; but this process is tedious and expensive, from the ... consumption of fuel. A shorter and more advantageous method of ... gold and silver has been discovered. A certain quantity of lead is put ... crucible with the alloy of gold and silver, the whole is exposed to the ... of the fire; and the lead being quickly converted by heat into an oxide, ... is easily melted into a semi-vitrified and powerful vitrifying matter, called ..., we have only to increase the proportion of imperfect metals; and, by ...ng with these imperfect metals, it communicates to them its property of ... very easily oxidated. By its vitrifying and fusing property, exercised ... upon the calcined and naturally refractory parts of the other metals, ...lerates the fusion, scorification, and separation of these metals. In this ... the lead is scorified, and scorifies along with it the imperfect metals. ...arates from the metallic mass, floats upon the surface of the melted mass, ... vitrified; but as the litharge would soon cover the melted metal, ... preventing the access of air, prevent the oxidation of the remaining ... metals, such vessels are employed as are capable of imbibing and ...ing in their pores the melted litharge, and thus removing it out of the .... for large quantities, vessels are so constructed that the fused litharge, ... being soaked in, may also drain off through a channel made in the ... of the vessel. Vessels made of lixiviated wood, or bone ashes, are most

proper for this purpose. These vessels are called *cupels*, the process itself *lation*. The cupels are flat and shallow. The furnace should be vault the heat may be reverberated upon the surface of the metal during the tion. A crust or dark-coloured pellicle is continually forming upon the s When all the imperfect metal is destroyed, and the scorification has ceas surface of the perfect metal is seen clean and brilliant, forming a kind geration called lightning. By this mark the metal is known to be refine

PASTE. Glass prepared in imitation of gems. The basis of all a gems is a very hard and pure silica, obtained by melting pounded quart an alkali, with the addition of borax, nitre, and different metallic oxides, ing to the intended colour of the gem. The materials should be of the kind, finely pulverized, well sifted, melted in crucibles of the best qualit the fusion should be continued in a potter's furnace for twenty-four hour more tranquil and continued it is, the denser the paste, and the grea beauty. The following are the ingredients, with their proportions, emplo the formation of some of the artificial gems. For what is called simply or strass, there are four different mixtures.

PASTES.	1.	2.	3.	4.
Rock crystal	·318	·3170	·300	
Minium	·490	·4855	·565	
Pure potash	·170	·1770	·105	·054
Borax	·021	·0200	·030	
Oxide of arsenic	·001	.0005		
Litharge				·540
Ceruse				·406
	1·000	1·0000	1·000	1·000

For *topaz*, there are the two following methods:—

	FIRST.	SECOND.
Strass, (white paste)	·95816	·990
Glass of antimony	·04089	
Purple of cassius	·00095	
Oxide of iron		·10
	1·00000	1·000

For *ruby* strass	·9755
Oxide of manganese	·0245
	1·0000

For *emerald*,—

Strass, (white paste)	·98743	·9905
Green oxide of copper	·01200	
Acetate of copper		·0080
Oxide of chromium	·00057	
Peroxide of iron		·0016
	1·00000	1·0000

For *sapphire*,—

Very white strass	·9855
Oxide of cobalt	·0145
	1·0000

For amethyst,

	FIRST.	SECOND.
Strass	·9870	·9979
Oxide of manganese	·0078	·0022
Oxide of cobalt	·0050	·0001
Purple of Cassius	·0002	
	1·0000	1·0000

For beryl, or aquamarine,

Strass	·9926
Glass of antimony	·0070
Oxide of cobalt	·0004
	1·0000

For Syrian garnet,

Strass	·6630
Glass of antimony	·3320
Purple of Cassius	·0025
Oxide of manganese	·0025
	1·0000

PASTE. A mucilaginous preparation of wheaten flour, incorporated with water by boiling. Sometimes powdered resin is mixed with it; also gum arabic, &c. &c., according to the peculiar wants of the artist or manufacturer. Alum is also considered to increase its cementing property.

PASTEBOARD. A thick kind of paper, made by pasting several sheets together, which are afterwards pressed or rolled, to give the fabric firmness and smoothness of surface.

PASTIL. A dry composition of odoriferous resinous matters, commonly employed to burn in chambers, to sweeten the air.

PATENT, or *Letters Patent*, is a writ or grant in the king's name, and under the great seal, designed to secure to the proprietor of any new invention the monopoly of its advantages for the term of fourteen years; but this term is sometimes extended, under extraordinary circumstances, by act of Parliament, to a longer period. The term patent is also applied to the right conveyed, as well as to the instrument conveying it. Monopolies, unless granted for a limited period, and with the view to the ultimate benefit of the public. During the reign of Elizabeth, many unmerited monopolies had been granted, which had so prejudicial an effect upon the commerce of the country, that, towards the end of that monarch's reign, the clamour was so loud and general as to induce her to send a message to Parliament, announcing her intention to immediately cancel the most oppressive of the exclusive privileges she had granted. But however just may be the feelings of opposition to monopolies in general, it will be readily allowed, that a patent for a new invention, for a few years, is only a just and reasonable compensation to the inventor, who is thus enabled to mature his discovery, and give it to the public, at the termination of his monopoly, in a perfect or highly improved state. And were it not for the exclusive privilege thus granted, many important inventions, that ultimately prove beneficial to the public, would never be persisted in, but entirely fail; as that powerful incentive would have no existence, which induces ingenious men to study and labour incessantly, and to expend large sums of money to bring their inventions into practical operation.

The basis of the present law of patents is derived from the 21st of James I., c. 3, which is regarded as the declaration statute; and the sixth section of this statute states, that patents for new inventions are exceptions to the general law of the statute. The general law is, that all monopolies, and all commissions, grants, licences, letters patent, &c. for the sole buying, selling, making, using, &c. of any thing, shall be void; the excepting clause declares, that "any declaration before mentioned shall not extend to any letters patent, and grants of privilege, for the term of fourteen years or under, hereafter to be made, of the sole working and making of any manner of new manufacture within this

realm, to the true and first inventor or inventors of such manufacturi others, at the time of making such letters patent and grants, shall nc as also they be not contrary to law, nor mischievous to the state, by ra prices of commodities at home, or hurt of trade, or generally inconven

The great importance of the subject of patents to engineers, machin manufacturers in general, renders it desirable to extend this article to an of the process of obtaining a patent; also the nature and conditions of tl and the expenses attending it; which information the writer of this ar compiler of the work is enabled to afford with perfect accuracy, he be fessionally a patent agent. It is by no means necessary that the appli a patent should employ an agent,—he may solicit the grant himself; tl however, but few persons whose experience and knowledge of the matt ciently qualifies them to transact the business of a patent with security own interests.

The first thing an inventor should attend to, is to endeavour to ascert has not been anticipated by others, which is not an unfrequent occ although rarely discovered until too late to benefit by it; owing, perhap injudicious flattery of friends, or the ignorance of legal advisers in m invention or discovery. Having determined the invention to be entire nal, and that it is calculated to compensate him for the expenses of a the inventor's first step to obtain one, is to make an affidavit of the fac invention before a Master in Chancery, if in London, or if in the country Master Extraordinary, in the following form; the words in italics being to afford precise examples.

(FORM.)

"*John Smith, of Birmingham, in the county of Warwick, Iron Founder,* oath, and saith, that he hath invented '*certain improved forms of appar the transmission and distribution of heat, the generation of vapours, and ot. cesses,*' which he believes will be of public utility; that he is the first a inventor thereof; that the said invention is entirely new, having nev practised nor used by any other person or persons, to the best of his kn and belief. (Signed) "JOHN S

"*Sworn at the Public Office in Southampton*
Buildings, this 6th day of March, 1834,
before me, "H. CROSS."

Before, however, the affadavit is made or acted upon, the inventor well consider the nature and words of the title or designation of his in for many patents have been annulled owing to the improper wording title. The law requires, that it shall form a true index to the specificati if it be so clear as to call the attention of rivals, and enable them to disc secret of the invention, before the patent has passed the great seal, the p may lose his privilege as well as his money. If, on the other hand, the title be so obscure as to incur the danger of a court of justice afterwards rulin is an imperfect definition of the invention, he will also forfeit his privilege. Cochrane was thus most arbitrarily deprived of his patent right for th rable street lamp which bears his name, owing to his having entitled the an "improved method of lighting cities, towns, villages." Now whe considered that no security whatever is afforded to the applicant until his has passed the great seal, and that he is, during this period, by too ex title, liable to be robbed of his right by impostors, the harshness and i of the decision just mentioned becomes very apparent. Latterly, howe judges have been somewhat more tender of the rights of patentees, to improved conduct the writer perhaps indirectly contributed. He was o during the passing of a patent for some gentleman, on the ground of the obscurity of the title, and he was required to render it more explicit; thi ever, he declined doing, as a compliance would be equivalent, in effe publication of the specification, as it was for one of those simple discov which a word more of explanation would have exposed the object to tho whom it should be kept secret. This fact he satisfactorily proved to the S General, who admitted the necessity of the course taken, and the op

was defeated. It was at the same time respectfully intimated to the Solicitor General, that if any additional information in the title were insisted upon, the patent would be declined altogether, and the intended manufacture be removed to France, where security against piracy would be afforded at the instant of signing a petition. The case mentioned is, however, an extreme one, and of rare occurrence; in most cases there is no difficulty whatever, though prudence dictates, that so important a step as the proper definition of an invention, on which the patent-right is founded, should be well considered.

The next step is to draw up a petition to the king, which contains a reiteration of the affidavit, and prays for the grant of the patent "for the term of fourteen years, according to the statute in that case made and provided." Here it becomes necessary to explain that patents for England, Ireland, and Scotland, are entirely separate and distinct from each other; and that when it is required to extend the grant to the British possessions abroad, the latter are included under the patent for England, at the additional cost of about five pounds. Supposing the application be for England alone, the prayer of the petition is expressed for "England, Wales, and the town of Berwick-upon-Tweed;" and should the Colonies be desired (which is rarely advisable), it is only necessary to add to the words just quoted, "and all your Majesty's Colonies and Plantations abroad." The petition, with the affidavit, is lodged at the office of the Secretary of State for the home department, for the king's pleasure, who directs, or rather is presumed to direct, the Secretary of State to refer the matter to the Attorney or Solicitor General for his advice thereon; the petition is, accordingly, endorsed with such reference, and signed by the Secretary of State, and, upon the payment of the fees, delivered to the applicant, who uses his discretion as to whether he had best take it to the Attorney or Solicitor General, being guided in his decision by the probability as to which of the two will execute the business with the least delay, and in the manner most satisfactory to the applicant. Upon receipt of the king's reference at either of the before-mentioned legal functionaries, the clerk examines the caveat book, to ascertain whether there be any existing caveats against the granting of a patent for a similar object to that expressed in the applicant's petition. If there be none, the clerk takes the earliest opportunity of drawing out the *report* in the usual form, to be ready for the examination and signature of his principal. The report thus completed, is, upon payment of the fees, delivered to the applicant, who transmits it to the king, through the medium of the Secretary of State's office. Before attending to what is done with it there, it is proper to notice the proceedings that would be taken in the case of there being interfering caveats,—and we may observe, by the way, that there are always numerous caveats against such inventions being patented as that expressed in the example of the affidavit we have furnished. Under these circumstances, the Attorney General's clerk (whose office, we will suppose, we have entered by preference,) writes a circular letter to each of the caveatees, informing them of the application, and adding this injunction,—"Should you consider the above to interfere with your caveat of [mentioning the date], an answer, post-paid, is requested within seven days of the date hereof, otherwise the patent will proceed." When the seven days have expired, and none have thought proper to answer, the applicant is entitled to his report; but should any answer, or "oppose," as it is called, such opposer must deposit with the Attorney General's clerk a sum equivalent to the expense of the hearing and the summonses (generally under five pounds). The Attorney General afterwards appoints a day when he will hear the rival inventors, or their agents, (and to these are sometimes added counsel, who are, however, generally only an incumbrance in the points relating to practical mechanics,) and each of these is summoned for the appointed day. When met together, the Attorney General first calls in the applicant, or his agent, who explains to him alone, and confidentially, the nature of his invention, and the leading points upon which he rests his claim of originality. The caveatee, or caveatees, are next heard in privacy; and if the Attorney General cannot make up his mind upon the first hearing, the rival parties are called in again alternately, and re-examined until he is satisfied. If he finds the inventions to be essentially alike, he refuses the patent to either

individually, but offers them a joint patent, if they will unite their interests in one: this recommendation, though rarely, has been sometimes adopted, and attended with advantageous results. In the case of the inventions being essentially different, the opponent is told so, and the applicant receives his report. A few days after this report has been delivered to the Secretary of State, a royal warrant is prepared, which is signed by the king. This warrant, which recites the prayer of the petition, the legal advice given to His Majesty, and other matters of form, concluding with directions to the Attorney General to prepare a bill for His Majesty's signature, is taken to the Bill-office (an office exclusively appropriated to the engrossing of patent bills, under the superintendence of the Attorney General,) where it is prepared in the course of a few days, or a week, and then delivered to the applicant, who takes it to the Secretary of State, to obtain the king's signature to it. The king having signed it, it is called the "King's-bill," and is next taken to the Signet-office, which, having passed, it is denominated the "Signet-bill." Hence it is conducted into the Privy Seal-office, where, having received the privy seal, it is baptized the "Privy Seal-bill," and is conducted to the Great Seal-office to receive the great seal, or finishing stroke. Formerly it had a more tortuous course of manufacture, having to go through a process at the Hanaper-office; but although this one of the many absurdities has been got rid of, the hanaper fees are still extorted, being made payable at the Great Seal-office before the patent can be obtained. We should here notice, that caveats are sometimes entered at the Great Seal-office; but opposition made by virtue of them, to the sealing of a patent, is made so expensive to the caveatee as to be now but rarely acted upon.

In the letters patent which are granted for new inventions, the improvements or inventions are first stated; the prayer of the petitioner to have the exclusive benefit for himself, or his assigns, for fourteen years, is next given, and this prayer is declared to be complied with, according to the statute. After commanding all subjects not to interfere with the patent right, and issuing a mandate to all officers not to molest the patentee in the exercise of it, the letters patent declare the patent void if it appear that the grant is contrary to law, or prejudicial to the subject; or if the thing invented have been in use before the date of the grant, or if the patentee be not the inventor, or if it interfere with prior letters patent, or if the patent be transferred to more than twelve persons (lately increased from five to twelve), or to any who act as a corporate body; or, finally, if the nature of the invention be not described, or the description or specification be not enrolled within *two* calendar months after the date of the letters patent. The letters patent conclude with a declaration, that they shall be construed in the most beneficial sense for the patentee.

It will be observed, that the period allowed for the enrolment of the specification, is but *two* months for an English patent only; but if the patentee declares in his affidavit that it his intention to solicit patents for Scotland and Ireland also, then he is allowed *six* months to prepare his specification; and if he declares for only one of these countries in addition to England, *four* months are allowed. These periods are, however, sometimes extended upon a special affidavit, and a petition to the Attorney General, setting forth the necessity of the extension. As an instance, we had occasion to solicit a patent for a gentleman, who discovered that the *kernel* of the palm-nuts, previously thrown away as valueless, contained more valuable oleaginous matter than the outer rind, from which the oil was usually extracted; and although the process for obtaining the oil could be specified by the operations that had been made upon a small quantity, still it was of importance that the public should be informed, through the medium of the specification, of the best mode of procedure on the large scale, to determine which, it was necessary to procure a supply from South America; on this plea, we procured *twelve* months to specify. However long a period a patentee may have to specify, he rarely finds it too much, very frequently, indeed, he is unprepared to supply all the details in a satisfactory manner to himself when he is required to complete his specification. For these reasons, we always recommend our clients to express in their affidavits that it is their intention to take out patents for the three kingdoms, if they have the remotest intention of so doing, as they thereby obtain *six* months to specify, which is a

advantage. The expression of an intention is not considered as obli- to do otherwise than just as the interest of the party may afterwards and when a patentee declines taking advantage of the longer term to he exposes himself to the liability of being robbed of his invention by a hus,—suppose A to have obtained in June a patent for improvements in the engine, and to have six months to specify. B invents other improvements steam engine, which he patents in July, and has only two months to B.'s specification is enrolled in September; then A goes to the office it, obtains, if he pleases to pay for it, an office-copy, takes it home and inserts, at his leisure, the whole, or as much of it as he pleases, in cification that is due in December; now as A has a prior claim by the date patent, B is irremediably robbed of his invention and his patent right too. btaining a patent for Scotland, the first proceedings are the same as for but the petition is referred to the Lord Advocate, upon whose report issues his warrant, and the remaining business is executed in Scotland requiring the king's signature to the bill. Four months is the time to specify a Scotch patent. The patent is written in the Latin language. oliciting an Irish patent, the affidavit and petition is sent with a refer- om the king to the Lord Lieutenant at Dublin; but as his lordship knows of such matters except the fees they conduct into his pocket, he refers er-discussed point of the propriety of granting the patent, to the grave ration of the Irish Attorney and Solicitor General, both of whom sign ames to a lithographed report, for doing which they pocket an enormous he subsequent proceedings are nearly similar to those of an English excepting that they are much longer in completion.

time required for completing an English patent under the most favour- rcumstances, that is without opposition, is three weeks; but by the pay- additional or "expedition" fees, it may be done in a fortnight by an gent. A Scotch patent takes also about three weeks; but an Irish takes full six weeks. Before the period when Mr. Stanley came into Secretary for Ireland, it was difficult to get an Irish patent completed months!

cost of patents for England, Scotland, and Ireland, are stated in a report of the Committee of the House of Commons, to be as follows:—

	£	s.	d.
For England, to one person only	106	11	8
" if to two persons, an additional .	20	0	0
" if the Colonies be included . .	5	0	0
For Scotland	79	10	5
For Ireland	128	5	11

xpenses of the specification are to be added to the foregoing, which entirely upon its length, the trouble of preparing it, and the quantity of gs. It cannot be less than ten pounds; and the average cost may be at about twenty pounds each, though there have been instances of the exceeding one hundred pounds, when it has been necessary to describe y very extensive mechanism, accompanied by numerous elaborate gs. The expense is frequently much increased by the inventor not well digested all his plans, and working drawings having to be made the head and from verbal descriptions, which generally require much on and study before they are complete. A material part of the before- ed costs of specifications, consists in the stamps and enrolment fees, ing, we think, to about half of the whole; the remaining half the compensation to the agent employed to write, making out the gs, &c. of the specification. But if the patentee feels himself competent ute this task in a proper manner, he may save himself this half of the ; nevertheless, if he has not previously been a patentee, and thereby acquainted with all the requirements of the law in this most essential ing, it would be imprudent in him not to avail himself of the advice or e of one more experienced in matters of the kind. The specification is ed upon parchment, the first skin bearing a five pound stamp, and every

succeeding skin, or second 1080 words, stamps of one pound each. Two sets of drawings are required, one on paper, the other on vellum or parchment; the latter are retained in the office, and are stitched to the copy of the patent on the "rolls." After this is done, the specification that was deposited, and the drawing on paper, will be returned to the patentee on application at the office; at which time the balance of the enrolment fees (a sum having been previously deposited) is demanded. The fees of enrolment of a Scotch patent are considerably more than for an English one, and the stamps are the same. The fees chargeable for an Irish patent, as well as the stamps, are less than those for an English one.

Since the foregoing was prepared for the press, an Act of Parliament for the amendment of the patent laws was introduced by Lord Brougham, and passed on the 10th September, 1835, of which the following is an abstract:—

"1. Any person who, as grantee, assignee, or otherwise, hath obtained letters patent for any invention, may enter with the clerk of the patents of England, Scotland, or Ireland, respectively, having first obtained the leave of the Attorney General, or Solicitor General in case of an English patent, of the Lord Advocate or Solicitor General of Scotland in the case of a Scotch patent, or of the Attorney General or Solicitor General for Ireland in the case of an Irish patent, a disclaimer of any part of either the title of the invention, or of the specification, stating the reason for such disclaimer; or may, with such leave as aforesaid, enter a memorandum of any alteration in the said title or specification, *not being such disclaimer or such alteration as shall extend the exclusive right granted by the said letters patent*; and such disclaimer or memorandum of alteration shall be deemed to be part of such letters patent, or such specification, in all courts whatever: Provided that any person may enter a caveat against such disclaimer or alteration; which caveat shall give the party a right to have notice of the application being heard: Provided also that the Attorney General or Solicitor General, or Lord Advocate, may, before granting such fiat, require the party applying to advertise his disclaimer or alteration, and shall, if he require such advertisement, certify in his fiat that the same has been duly made.

"2. If, in any suit, it shall be proved, or specially found by the verdict of a jury, that any person who shall have obtained letters patent for any invention, was not the first inventor thereof, or of some part thereof, by reason of some other person or persons having invented or used the same, or some part thereof, before the date of such letters patent; or if such patentee or his assigns shall discover that some other person had, unknown to such patentee, invented or used the same, or some part thereof, before the date of such letters patent; or if such patentee or his assigns shall discover that some other person had, unknown to such patentee, invented or used the same, or some part thereof, before the date of such letters patent, it may be lawful for such patentee, or his assigns, to petition His Majesty, in council, to confirm the said letters patent, or to grant new letters patent; which petition shall be heard before the judicial committee of the privy council; and such committee, upon being satisfied that such patentee believed himself to be the first and original inventor, and that such invention, or part thereof, had not been publicly and generally used before the date of such first letters patent, may report their opinion that the prayer of such petition ought to be complied with; whereupon His Majesty may, if he think fit, grant such prayer: and the said letters patent shall be available in law and equity to give to such petitioner the sole right of using, making, and vending such invention as against all persons whatsoever, any law, usage, or custom to the contrary thereof notwithstanding.

"3. If any action at law, or any suit in equity for an account, shall be brought in respect of any alleged infringement of letters patent, or any *scire facias* to repeal such letters patent, and if judgment shall pass for the patentee or his assigns upon the merits of the suit, the judge may certify that the validity of the patent came in question before him, which certificate being given in evidence in any other suit or action whatever touching such patent, if judgment shall pass in favour of such patentee or his assigns, he or they shall receive treble costs, to be taxed at three times the taxed costs, unless the judge shall certify that he ought not to have such treble costs.

"4. If any patentee shall advertise in the London Gazette three times, and in three London papers, and three times in some country paper, published in the town where, or near to which, he carried on the manufacture of any thing made, according to his specification; or near to, or in which he resides, in case he carried on no such manufacture; or published in the county where he carries on such manufacture, or where he lives, in case there shall not be any paper published in such town, that he intends to apply for a prolongation of his term of sole using and vending his invention, and shall petition His Majesty in council to that effect; any person may enter a caveat; and if His Majesty shall refer the consideration of such petition to the judicial committee of the privy council, and notice shall first be by him given to any person or persons who shall have entered such caveats, the petitioner shall be heard by his counsel, and witnesses, to prove his case, and the persons entering caveats shall likewise be heard by the counsel and witnesses; whereupon, and upon hearing and inquiring of the whole matter, the judicial committee may report that a further extension of the term in the said letters patent should be granted, not exceeding seven years; and His Majesty is, if he shall think fit, to grant new letters patent for the said invention for a term not exceeding seven years after the expiration of the first term: Provided the application by petition shall be made and prosecuted with effect before the expiration of the term originally granted in such letters patent."

5 and 6 introduce some alterations in the forms of process in actions for infringement.

"7. That if any person shall write, stamp, &c. upon any thing the name, or any imitation of the name of any other person who hath obtained letters patent for such thing, without leave in writing; or if he shall write, stamp, &c. on such thing without leave, as aforesaid, the words 'patent,' 'letters patent,' or 'by the King's patent,' or any words of the like kind, meaning, or import, he shall, for every such offence, be liable to a penalty of 50*l*."

It is necessary we should not omit to inform the reader that very recently an Act was introduced by the Duke of Richmond, and received the sanction of the legislature, for the abolition of voluntary and extra-judicial oaths and affidavits; by the provisions of which it is now indispensable that an inventor who applies for a patent should first make a "*declaration*" in lieu of the affidavit, of which we have given the form on page 266; and this declaration must be couched in the terms expressed in the Act, which we have not space to insert.

PAVING, or PAVEMENT. A layer or covering of stone or brick, carefully laid over roads, paths, halls, passages, &c., and to form stone floors in the interior of buildings. Pavements of flint and flags, in streets, are commonly laid dry, that is, in beds of sand or gravel; those of stables, courts, ground-rooms, &c. are laid in a mortar of lime and sand, or in lime and cement, especially if there be cellars underneath. Sometimes, after a floor of stone or brick has been laid dry, a thin stratum of mortar is spread over it, and worked into the crevices, to fill up all the joints. The several kinds of paving are as various as the materials of which they are composed, the adoption of which depends usually upon local circumstances and the expense: the following are the principal kinds.

1. Pebble-paving, frequently laid in ornamental design, is done with kidney-shaped stones, obtained from Guernsey and other places; it is extremely durable when properly performed.

2. Rag-paving, formerly much used in London: the stone is obtained from Maidstone, in Kent, whence the name of Kentish rag-stone; there are square stones of this material for coach-tracks and footways.

3. Purbeck pitchens; stones from six to ten inches square, and five inches deep, brought from the island of Purbeck, and frequently used in court-yards.

4. Square-paving, by some called Scotch-paving: by this was recently understood cubical stones, of blue whynn; they are, however, now nearly disused in London, owing to their inferiority of the next-mentioned.

5. Scotch granite; a hard material, usually of a bluish or reddish colour, with which the London road-pavements are formed.

6. Guernsey and Herm blue-granite; extensive quarries being now opened in the latter island, chiefly for the supply of the London pavements, for which purpose it is found to answer as well, if not better, than the Scotch. The stones

are prepared of a prismoidal figure, by means of iron hammers, and are usually laid with their end downwards, bedded in gravel.

7. Purbeck-paving, of the blue sort, in large surfaces, and about 2½ inches thick, make excellent flag pavements.

8. Yorkshire-paving, of large dimensions, is equally good with the former; is impervious to water, and unaffected by frost.

9. Ryegate, or firestone-paving, is used for hearths, stoves, ovens, and such places as are liable to great heat, which does not affect the stone, if kept dry.

10. Newcastle flags are about two feet square, and two inches thick: answer well for out-offices.

11. Portland-paving, from Portland, sometimes interspersed with black dots.

12. Swedland-paving is a black slate, dug in Leicestershire; much used in paving halls, especially in party-coloured paving.

13. Marble-paving, frequently variegated with different coloured marbles, and sometimes inlaid in mosaic.

14. Flat-brick paving, done with brick laid in sand and mortar, or groute, as when liquid lime is poured into the joints.

15. Brick-on-edge paving, done with brick, laid edgeways, in the same manner.

16. Bricks laid flat or edgeways, arranged in herring-bone fashion.

17. Bricks set endways in mortar, sand, or groute.

18. Paving-bricks, made especially for the purpose.

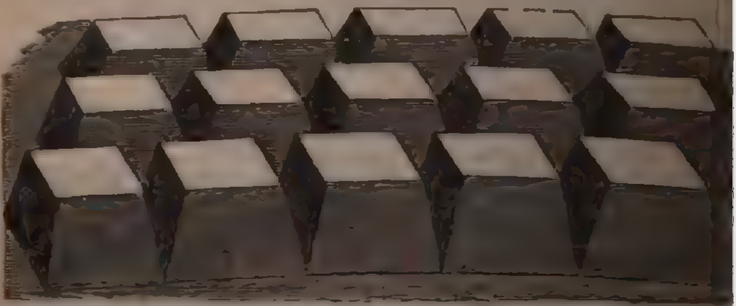
19. Paving with ten-inch tiles.

20. Paving with foot tiles.

21. Paving with clinkers, for stables, &c.

There are many other kinds of paving, equally worthy of notice with the foregoing, but it would be needless to extend the description. We must not, however, omit to mention a beautiful imitation of mosaic, in various colours and designs, now manufactured of pottery-ware, some specimens of which we have seen at the Museum of National Manufactures and the Arts, in Leicester-square. Pavements of churches and other handsome buildings frequently consist of stones of various colours, but chiefly black and white, in squares or lozenges, artfully disposed. There needs no great variety of colours to make a surprising diversity of effect. It has been shown, that two square stones divided diagonally into two colours, may be joined together, in chequer sixty-four different ways, as each admits of four different situations, in each of which the other square may be changed sixteen times, which gives sixty-four combinations. A very beautiful example of a tesselated pavement, in black and white, is afforded in the extended floor of St. Paul's Cathedral, which is well worthy of examination by those who have occasion for works of that nature.

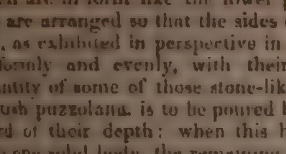
Having stated the various kinds of pavement as commonly practised by masons, we proceed to notice several deviations from that practice, which have been much talked of, and partially brought into use. The first we shall describe is the patented improvement of Mr. Abraham H. Chambers, of New Bo[…]



street, London; the object is for paving the horse and carriage-ways of the public streets. Mr. Chambers forms the bed of earth or gravel of the same figure, which is a slightly elevated arch; this foundation is to be rendered […]

firm and solid as possible, by ramming, previous to laying down the stones, which are in form like the lower portion of a regular quadrangular pyramid, and are arranged so that the sides of each stone shall overlap those in the next row, as exhibited in perspective in the preceding cut. When they are thus laid uniformly and evenly, with their broadest surfaces or bases downward, a quantity of some of those stone-like cements, of which lime is the basis, or the British puzzolana, is to be poured between the joints, filling them to about one-third of their depth: when this has become hard, so as to cement the whole into one solid body, the remaining two-thirds of the interstices are to be filled with broken flints, granite, or other hard materials. On each side of this roadway are to be constructed deep brick gutters, for the reception of the water, and the small portion of mud that may be formed; and midway, between each side and the centre of the road, lateral trenches are to be dug, to lead, by an oblique descent, into the brick gutters: these trenches are to be filled with broken bricks and stones, and serve as a filter, to convey nothing but the water from the middle of the road into the gutters. The patentee considers that a paved carriage-way, constructed upon this plan, will be extremely durable, and will be kept free from mud and sludge.

The patent *triangular pavement* is founded (as the inventor states), upon the reciprocal bearing and support of the stones. The pavement is formed of granite, or other hard paving stones, of the ordinary size, and each stone is laid arranged in such a manner, with reference to the several contiguous stones, as that neither can be displaced the eighth of an inch, by any pressure or percussion, however great, in the ordinary use of the streets. The stones are not wedges or cubes, but formed as represented in the subjoined diagram, each containing a protruding or salient angle on the one side, and an indented or receding angle on the opposite side; the receding angle being formed to receive the salient one. Although the first cost of a pavement of this kind may be greater than ordinary, its probable greater durability will, most likely, more than compensate; besides, its level symmetry, neatness, and solidity of construction, derived by each part from the whole superficies, seem to be advantages attached to this species of pavement.



In Macknamara's patent pavement, the stones are comparatively thin, flat squares; their upper faces have two of the opposite sides of the quadrangle beveled off to an angle of about forty-five degrees; and underneath each stone the reverse sides of the quadrangle are beveled off in like manner, so that when laid together in the manner exhibited in the engraving on the next page, they may reciprocally support each other. *Fig.* 1 represents a plan of a street paved on this system; *Fig.* 2 exhibits a vertical section of the same, the roadway stones being numbered 1, 2, 3, 4, 5, (as shown on the plan); 6 6 are the gutter-stones; 7 7, those which abut against the curb. *Fig.* 3 gives a side view of two entire stones, exhibiting the reverse position of the beveled edges, by which the stones are mutually supported. *Fig.* 4 represents the opposite sides or edges of the same stones.

"By a careful attention to the figures, it will be seen," says the patentee, "that each and every individual block or stone mutually and reciprocally support, and are supported by, each other. This principle will be found to apply throughout, each block or stone being upheld by two adjoining ones, and, in return, mutually supporting others that are made to rest upon it. These blocks may be made of any convenient size; the principal object to be attended to is to make the bounding lines on the upper surface as perfect as the nature of the stone will admit. I shall here observe, that when blocks are used of large dimensions, it will be proper to groove their surfaces to form a better foot-hold for horses; and in order to identify my invention, and thereby endeavour to prevent any infringement on this patent, that it consists solely in working, cutting, or forming the sides of my blocks or stones, so that they shall make

alternately obtuse and acute angles, with the upper surface of the block or stone which, being done, they may be so arranged or combined, that they will

Fig. 1.

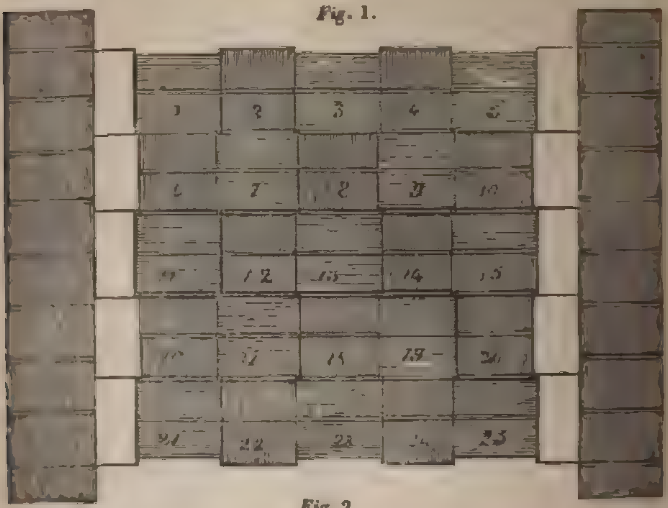


Fig. 2.

Fig. 3.

Fig. 4.

mutually and reciprocally support and preserve each other from the imperfection so generally found in the usual practice of paving."

PEARLS. A calculus or morbid concretion, formed in consequence of some external injury which the muscle or shell-fish receives that produces it, particularly from the operations of certain minute worms, which occasionally bore even quite through to the animal. The pearls are formed in the inside, on these places: hence it is easy to ascertain, by the inspection of the outside only, whether a shell is likely to contain pearls. If it be quite smooth, without cavity, perforation, or callosity, it may with certainty be pronounced to contain none; if, on the contrary, the shell be pierced or indented by worms, there will always be found either pearls, or the embryos of pearls. It is possible, by artificial perforation of the shells, to cause the formation of these substances. The process which has been chiefly recommended is to drill a small hole through the shell, and to fill it up with a piece of brass wire, riveting this on the outside, like the head of a nail; and the part of the wire which pierces the interior shining coat of the shell will, it is said, become covered with a pearl. As to the value of British pearls, some have been found of a size so large as to be sold for 20*l.* each, and upwards; and 80*l.* was once offered and refused for one of them.

The *oriental pearl muscle*, to which we are indebted for nearly all the pearls of commerce, has a flattened and somewhat circular shell, about eight inches in diameter, the part near the hinge bent or transverse, and imbricated, or covered like slates on a house, with several coats, which are toothed on the edges. Some of the shells are, externally, of a sea-green colour, others are chestnut or reddish, with white stripes or marks, and others whitish, with green marks. These shells are found both in the American and Indian seas. The principal

pearl fisheries are off the coasts of Hindoostan and Ceylon; they usually commence about the month of March, and occupy many boats, and a great number of hands: each boat has generally twenty-one men, of whom one is the captain, who acts as pilot; ten row and assist the divers; and the remainder are divers, who go down into the sea alternately, by five at a time. The largest round pearl that has been known belongs to the Great Mogul, and is about two-thirds of an inch in diameter. Pearls from the fishery of Ceylon are considered more valuable in England than those from any other part of the world. The smaller kinds are called seed or dust pearls, and are of comparatively small value, being sold by the ounce, to be converted into powder. To make the artificial, take the blay or bleak fish, common in the Thames; scrape off the silvery scales from the belly; wash and rub these in water; then suffer this water to settle, and a sediment will be found, of an oily consistence. A little of this is to be dropped into a hollow glass bead, of a bluish tint, and shaken about so as to cover all the internal surface: after this the bead is filled up with melted white wax, to give it solidity and weight.

The Roman pearls are formed of a very pure alabaster, considerable quarries of which exist near Pisa, in Tuscany. The process is as follows:—the alabaster is first sawn into slices, the thickness of the pearls required; the pearls are then formed with an instrument which bores a small hole in the centre, at the same time that the required shape is obtained. The next thing in the process is their immersion in boiling wax, to give them a rich yellow hue, and afterwards to cover them several times with the silvery substance obtained from the scales of the bleak. The singular beauty of this ornament, which perfectly resembles the real pearl, the varied patterns in which they are arranged, and their extreme cheapness, render them an object much sought after; while their solidity is such, that they may be dashed to the ground with violence without receiving the slightest injury; being thus rendered far superior to those of French manufacture, which are at once more fragile, and considerably less imitative.

The Chinese in a manner force the production of real pearl, in the animal itself. They collect the myca margarite fera, or European pearl muscle, and pierce the outsides of the shells in several parts, without completing the perforation throughout. The animal, becoming conscious of the weakness or deficiency of the shell in those particular spots, deposits over them a great quantity of its pearly calcareous matter, and thus forms so many pearly tubercles over them. The pearls thus obtained are, however, said to be generally inferior to those naturally produced. Pearls that are discoloured may be thus whitened: "Soak them first in hot water, in which some bran with a little tartar and alum have been boiled; rub them gently between the hands, which may be continued until the water grows cold, or until the object is effected, when they may be rinsed in lukewarm water, and laid on writing-paper, in a dark place, to cool." The foregoing is extracted from the scientific journals; but we have always understood that real pearls, so discoloured, are scaled by the lapidaries, that is, they take off the upper coat or lamina, which leaves them slightly diminished in size, but equally beautiful to their primitive state.

PEARL, Mother of. The shell, not of the pearl oyster, but of another kind of oyster, the inside of the shell of which is very smooth and polished, and of the whiteness and water of pearl itself. The shell has the same lustre on the outside, after the outer coat, or lamina, has been removed by aqua-fortis and the lapidary's mill. It is used for the handles of knives, inlaid work, &c.

PEARLASH. An impure potash, obtained by lixiviation of the ashes of plants. See Potash.

PEARL-SHELL. A new process of working pearl-shell into a variety of devices, for the purpose of applying it to ornamental uses in the manufacture of japan ware and other articles, has lately been invented by Messrs. Aaron Jennings, and John Betteridge, of Birmingham. The process is similar to that of engraving on metals in relief, by the aid of corrosive acids and the etching-point. The pearl-shell is first divided into very thin plates or leaves, such as from the 40th to the 100th part of an inch, and the devices or patterns are drawn

upon them in an opaque turpentine varnish; strong nitrous acid is then brushed over the plates repeatedly, until those parts left bare, or undefended by the varnish, are sufficiently corroded, or "eaten away" by the acid. The varnish being now washed off by a little oil of turpentine, the device, which the acid has not touched, is found to be perfectly executed. If the design is to be after the manner of common etching on copper, then the process upon the shell is precisely similar to that already explained under the article ENGRAVING. When a considerable number of ornaments are required of the same size and pattern, a sufficient number of the plates are cemented together by glue, with only one plate, having the device etched upon it, placed on the outside; these are then made fast in a pair of clams, or screwed between the jaws of a vice, and carefully sawn out altogether by a very fine frame-saw: the cemented shells are then thrown into warm water, which softens the glue, and quickly separates the pieces. When several devices upon a plate have been bit in, they may be laid upon a flat surface, and cut through with a knife-edged tool; for thick pieces the saw is put in requisition, and the finishing executed by a variety of sharp gravers and instruments.

PEARL-WHITE. An oxide of bismuth. It is employed as a cosmetic, to whiten the skin; but its tendency to become black, by exposure to the action of sulphuretted hydrogen mixed with the atmosphere, renders it a very dangerous expedient to heighten female charms.

PEAT. A spongy black earth, combined with decayed vegetable matter when dried, it forms a valuable fuel.

PECK. An English measure; the fourth part of a bushel.

PEDOMETER, *foot-measure*, or *way-wiser*, is a machine in the form of a small time-piece, containing a train of toothed wheels, which, by means of a chain or string, fastened to a man's foot, or to the wheel of a carriage, are made to move one notch or tooth at each step, or each revolution of the wheel, and the train thus uniformly moved being connected to an index, points out the distance travelled, on a graduated dial-plate.

A patent for "an improved pedometer for the waistcoat pocket, upon a new and very simple construction," was taken out by Mr. William Payne, of New Bond-street, in 1831. It is of the form, and of the usual size, of a common watch, and consists of a lever or pendulum, one end of which is weighted or inlayed, and the other supported by a delicate spring; by which arrangement, each step of the wearer produces a vibration, and moves a ratchet wheel one tooth, and the latter being geered into a train of wheels (similar to those of a common counting machine) moves indexes or hands over the face of a dial-plate, on which the number of vibrations or steps are indicated. The patentee also attaches his pedometers to an ordinary watch, in which case, the train of wheels and other parts are placed under the dial-plate or face of the watch.

PEN. A well-known instrument for writing. In the earliest ages, writing was executed with styles of metal or other hard substance, which, after a time, were superseded by pens and coloured inks. The first pens were made of reeds, or small hard canes, about the size of the largest swan quills, cut and split in the same manner as the pens in present use. According to Isidore, and some other writers, *quill-pens* were first introduced about the year 636; they did not come into general use, however, till the middle of the seventh, and were not common till towards the close of the eighth century. Reed-pens continue to be employed up to the present time, for writing some of the oriental languages and by artists, for sketching outlines. The greater number of pens now in use are made from the quills of the goose—those of the swan, turkey, duck, and crow, being occasionally employed—the two latter exclusively for very fine writing or drawing. As the making or mending of quill-pens is to many persons difficult of attainment, and to all, at times, inconvenient, various attempts have been made to render the process less frequently required. One of these methods consisted in arming pens made of turkey-quills with metallic points or nibs, by which their durability was somewhat increased, although at the expense of the natural elasticity of the quill; nor was the durability sufficiently extended to be commensurate with the additional cost. To do away with these

frequent pen-mending, Mr. Bramah took out a patent for an im- in pens, which consisted in dividing a quill longitudinally, and cut- four or six lengths, according to the size of the barrel. Each of formed a pen—some two, by being cut at each end. The pens were held in a jointed silver holder, which imparted great firmness while it permitted the free action of the nibs. Pens have been horn, also from tortoise and other shells; but no useful application been made of such pens, as they are more expensive and even less than those made from quills. Some successful attempts have been the nibs of pens of precious stones, in order that they may be used without wear or corrosion. The first that we recollect were introduced Hawkins and Mordan, whose specification of 1823 states, that they of tortoise-shell or horn, instead of quills; and when the material is , these parts are softened in boiling water, and then small pieces of ruby, or other precious stones, are imbedded into them by pressure; , it is said pens of great durability as well as elasticity are made. bility to the nibs, the patentees proposed to affix to the tortoise-shell, pieces of gold or other metal, and attaching the same by the tioned or any other convenient means, as cement or varnish. It is ggested that springs may be placed on the back of the pen, as shown xed figure, which may be slided backward or forward, elasticity according to the different hands that may be writing. We are informed by a gentleman who had pens many months in constant use, that it had exhi- gns of deterioration or wear. Mr. Doughty, of Great reet, has likewise devoted much attention to the con- of pens, the nibs of which are rubies set in fine gold. aid to write as fine as a crow-quill, and as firm as a —to possess considerable elasticity, and produce an uniform , unattainable by ordinary pens. Mr. Doughty states, of his ruby pens have been in constant use upwards , and continue still perfect; and that if a little care of the nibs, by preventing their being struck against

nces, and occasionally washing them with soap and water, with a ng, they will be found, notwithstanding their first cost, *economic* rhodium pens, consisting of two flat strips of gold placed angularly , and tipped with a hard metallic alloy, are very durable, though the ruby nibbed. Under the head INKSTAND, we have given Mr. contrivance to prevent injury to his pen-nibs in dipping for ink.

decided attempt to introduce *metallic pens* to general use, was made , whose "perpetual pens" will doubtless be remembered by many ers. The name of Wise was rendered conspicuous in most of our hops, some twenty-five or thirty years since, as the original inventor manufacturer of the steel pens; they consisted of a barrel-pen of steel, a bone case, for convenience for carrying in the pocket. Notwith- productions possessed but in a very remote degree the requisite pro- writing instrument, and were extremely dear, he managed to make a lhood out of the business, by dint of unwearied exertions in promoting Mr. Donkin subsequently made some excellent steel pens, but the price nd the demand inconsiderable. This description of pen has recently much improved, especially by Mr. Joseph Gillott, of Birmingham, who manufacturer of steel pens in the world, converting annually upwards of fine steel into writing pens. The improvement has been accom- employing metal of a better quality in a thinner and more elastic aking the slit shorter, and by more carefully attending to the finish of the pens. These improvements in quality have also been attended t a reduction in price, that a *gross* of the improved steel nibs may chased for very little more than was formerly charged for *one* of Wise's common three-slit pen, that is, the pen with a slit on each side of lit, is with many persons still a favourite, and some of these pens

seem to embody most of the advantages of which metallic pens are susceptible. Their present excellence and extreme cheapness seems to promise the almost entire disuse of quills, although, up to the present time, there has been no falling off in the demand for this article.

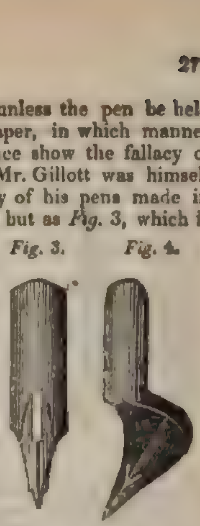
Mr. James Perry, of London, has contributed, we believe, more than any other individual to the introduction of the modern improved steel pens; he has brought out several steel pens of a very ingenious and original description, and devoted more than ordinary attention to the forming them to suit a variety of hands and tastes, which he regularly classed, advertised, and humorously puffed in rhyme, by which means he acquired a celebrity to which no previous pen-maker had attained. Mr. Perry first overcame the extreme rigidity of the ordinary steel pen, by the introduction of apertures *between the shoulders and the point*, thereby making them elastic below instead of above the shoulder: this was the subject of his patent of 1830. "The double patent Perryian pen," the merits of which have been so much placarded throughout the kingdom, received its odd cognomen from the circumstance of a second patent taken out by Mr. Perry, in 1832; the pens described in the specification of which are represented as combining the superlative qualities of both inventions. *Fig.* 1 is a sketch of Mr. Perry's "double patent pen," which distinctly shows the position of the aperture and the lateral slits, by which a great degree of elasticity is obtained. *Fig.* 2 is Mr. Perry's ingenious "regulating-spring pen," consisting of one of his patent pens, with the addition of a sliding spring, which increases or diminishes the flexibility of the pen, according as it is placed further from, or nearer to the point. In another instance Mr. Perry employs the elasticity of Indian-rubber, by twisting a thread of this material round the nibs of the pen, the yielding of which permits the opening of the points, in proportion to the pressure applied. The care which Mr. Perry takes in the correct manufacture of his pens, has mainly contributed to the general preference given to them; for, however excellent may be the principle of the structure, if the workmanship of the nibs be not nicely performed, the pens will not write well. It is from defects of this kind, we believe, that many apparently excellent metallic pens, that have been successively brought out, have met with a comparatively small sale.

Fig. 1. *Fig.* 2.

As the extremities of the nibs of metallic pens of the ordinary form become worn, they progressively increase in breadth, until they become useless, unless their original form should be restored by skilful filing, or grinding, upon an oil-stone: these being operations which no economist of time will perform, at the present low prices of the article, Mr. Gillott, of Birmingham, took out a patent in 1831 for an improvement in metal pens, designed to remedy the defect mentioned. This he proposed to effect by making the nibs of his pens parallel sided, that is, an equal breadth to the points for about an eighth of an inch long, the remaining portion or upper part of the nibs being cut either inclined in the usual manner, or terminating with a shoulder next to the parallel nibs. "The whole length of such nibs," says Mr. Gillott, "may of course be worn away, without increasing the breadth of the strokes in writing." This construction, it however appears to us, will not only fail in obtaining the advantages sought, but will entail disadvantages to which the tapered form is comparatively free; namely, a greater tendency to take a set in opening during the downward strokes of the pen, and a deficiency of reacting force in the up-strokes to bring the nibs together; the narrowness of the points also prevents the ink from flowing down in sufficient quantity to give a constant and unfailing supply. Mr. Gillott, although a pen manufacturer, is evidently no great pen-user, for all persons who are in the habit of using steel pens know that in a short time the abrading action of the paper, produces a basil edge on the under side of the nib, converting it into a very efficient chisel, which, catching the paper in the up strokes, renders the pen unfit for further use. With respect to their

wearing away uniformly, this can never be the case, unless the pen be held vertically, that is at right angles to the plane of the paper, in which manner ordinary writing cannot be executed. This will at once show the fallacy of Mr. Gillott's proposition; and it would appear as if Mr. Gillott was himself conscious of the error; for we have never met with any of his pens made in accordance with his patent, that is, with *parallel* points, but as *Fig.* 3, which is one of Mr. Gillott's pens, as now manufactured; otherwise this is a pretty good pen, and ranks with the best of the *three-slit* class.

Fig. 3. *Fig.* 4.



The position in which a pen is usually held causes the wear to take place in an inclined direction, slightly rounded at the edges, and the right hand nib to be more worn than the left. When one nib becomes shorter than the other, the longer nib bears harder than the shorter upon the paper in the up-strokes, and produces thick and blotted writing. It was probably with a view of obviating these effects that the scribes of olden time wrote their letters either upright, or inclining to the left hand, both of which modes are retained by the lawyers. Making due allowance for the obsoleteness of many of the characters, we think it must be admitted that such writings possess more clearness and intelligibility of form than our modernized writing.

In order, however, that we may be able to incline our letters in the *right* direction, and yet save our pens from rapid destruction, Messrs. Mordan and Brockedon introduced, and patented in 1831, pens with inclined slits, which they very appropriately designated the "oblique pen." It has been stated, as a well-authenticated fact, that ninety-nine persons in every hundred fail to attain, permanently, the art of writing with a pen in the true position; that is, with the hand removed a little to the right, and the tip of the pen pointing to the right shoulder, when the slit of the pen will be in the direction of the writing, and both of the nibs addressed fairly to the paper. *Fig.* 4 is a representation of Messrs. Mordan & Co.'s oblique pen. The direction of the slit in this pen being that in which the writing usually slopes at an angle of about thirty-five degrees, both nibs are brought equally down upon the paper—the writer is not restricted to any particular position, but at liberty to use the pen freely, without the restraint of attitude, so strongly insisted upon by teachers of writing. The action of the oblique steel pen is altogether remarkably good, and, from the shape of the nibs immediately below the shoulder, it has a most excellent spring, producing a pleasing effect both in the up and down strokes of the writing; it glides smoothly over the paper, and is altogether free from the harshness so much complained of in steel pens. These oblique pens are made of the best steel, in a very thin and highly elastic state; the arched form gives the requisite strength, where it is necessary they should be firm and unyielding, and also enables them to carry more ink than any previous pens. The advantageous property of this particular form, for holding a large quantity of ink, was at once perceived by other manufacturers, and led to the construction of the Lunar, Gonidon, and some other similar pens. Messrs. Mordan & Co.'s specification describes a variety of modifications of pens and pen-holders, illustrated by numerous figures. In the first place are shown quill-pens and portable pens, (the latter implying short pieces,) having inclined slides, and metal pens similarly formed. To apply the principle to pens cut in the usual manner, with straight or longitudinal slits, handles are provided, which have at their lower ends curved metal arms, with clips or holders, which fix the pens at an angle, varying from thirty to forty degrees out of the line formed by the handles. Some of these pen-holders are furnished with joints and set-screws, to enable the writer to place the pens at such an inclination, with respect to the handle, as to accord with the inclined position of the letters he is making. The latest improvement in steel pens is one by Mr. Gowland, consisting in the introduction of an additional nib. The following engravings represent three pens of this

description, as manufactured by Messrs. Mordan & Co., under a recent pat *Fig.* 5 are back and side views of Messrs. Mordan and Co.'s patent three-nib

Fig. 5. *Fig.* 6. *Fig.* 7.

slip-pen. *Fig.* 6 are similar views of their patent three-nibbed *flat-spade*, as the Birmingham manufacturers call it, the *lunar pen*. In each of these pen the additional nib is formed by cutting it out of the stem or shank of the pe where there is always a superfluity of metal, and turning it back over the oth nibs. *Fig.* 7 are back and side views of Mordan & Co.'s patent three-nibb *counter-oblique pen*. Many persons having been strongly prejudiced again the one-sided appearance of the original oblique pen, Messrs. Mordan & C were induced to attempt an improvement in this respect, and they have ful succeeded. The improvement has been accomplished by the introduction of additional shoulder, opposed to the former. This novel and curious pen h been very much admired, and it is as useful as curious; it has the advantage holding a very considerable quantity of ink, and of retaining, from its obliquit a position adapted to the slope of the writing, while to the eye a perfect equ librium is preserved. The effect of the third nib in metallic pens, is to enable th pen to carry a larger quantity of ink, and to force it down in uniform and nev failing succession to the paper. Every time such pens are pressed on the dow strokes of the writing, the ink flows in a body towards the point from the eff of capillary attraction, at the precise time when it is most wanted. This result produced by the third nib forming a conical tube with the other nibs of the pe with its smallest end downward, and always causes the ink to flow equally much on the centre of the down-strokes as the two points of the pen itse The capillary attraction, which is brought into operation in this ingenious co trivance, completely counteracts the defects existing in other pens, arising fro the opening in the slip tapering in the opposite direction to that which is requ site, for the purpose of fairly conveying the ink to the paper; of this any o may convince himself by pressing the points of any ordinary pen on the thum nail, until the slit opens wide enough for large-text writing, when the ink w instantly recede from the points towards the upper extremity or angle of th slit. Capillary attraction always causes fluids to flow towards the narrowe part or opening of every conical tube; and, therefore, in three-nibbed pe the ink is forced down upon the paper, and the thickest ink would be propell downwards most effectually by the action of the three nibs. Another advanta of the third nib is, that it clears the slit of the pen, removing the fibres as th are gathered from the paper, thereby removing the greatest objection that h hitherto existed to the use of metallic pens.

The following is the process of making steel pens, as witnessed at the exte sive and well-conducted manufactory of Messrs. Mordan & Co., Castle-stree Finsbury, whose liberality, condescension, and urbanity to visitors on all occ sions, is gratefully acknowledged by many individuals who have in vain ende voured to obtain a sight of this interesting process elsewhere. A hardened ste punch and matrix, of the exact size and shape of the pen to be made, havin been attached to a powerful fly-press, sheet steel of the finest quality, reduce to about $\frac{1}{100}$ of an inch in thickness, and in strips of two inches and a half wid

..., and every pen is struck out singly, till the metal is exhausted. In this ... pens are called *blanks* or *flats*. After cutting out, the next operation ... ing or annealing; this is performed by putting a great number of the ... an iron box, with a small quantity of tallow on the top of them; the box ... ut up close, is placed in a furnace, and there kept until the box appears ... ually heated all over. The box is then withdrawn, and the pens emptied ... some hot ashes, covered with the same, and left to cool gradually. By ... ns the pens are sufficiently softened for the subsequent process; but as ... are very rough and scaly from the effects of the fire, they are first ... by being placed in a mechanical agitator with sand, ashes, &c., and ... aken for an hour or two, which renders them remarkably clean and ... The makers' name having been stamped on the shank of each pen, ... apertures, if any, cut out, they are marked for the slits. This is done ... very sharp chisel, worked by a fly-press, and so exquisitely adjusted as ... cut through two-thirds of the thickness of the metal. This done, the ... eration is the dishing. A hardened steel punch, of the precise form to ... to the pen, being attached to a fly-press, a die is placed beneath to ... it; the die being concave, and the punch convex, and both being made ... fit each other with the greatest accuracy, the *flat* is forced into the ... the die, and retains permanently the form thus given to it. The pens ... shed are next hardened, by being placed in the iron box, and heated as ... softening process, except that they are now cooled suddenly, by being ... into a vessel of cold water or oil. When the pens are quite cold, they ... out of the water, and placed in a cullender to drain. When dry, they ... into the agitator with a quantity of sawdust, and shaken for a conside... ..., which cleans and polishes them, giving a degree of smoothness and ... the nibs unattainable by any other method equally economical. The ... is an ingenious piece of mechanism, invented by Mr. Mordan; it con... a large tin cylinder, supported horizontally by two cranked axles—one ... end,—upon a strong iron frame; another axle, mounted upon anti-... wheels, at the end of the machine, carries a winch handle and a heavy ..., upon this axle is also placed a driving wheel, a rigger-band from ... puts the crank in motion, and communicates a very rapid elliptical move-... the cylinder and its contents. By this contrivance the pens are very ... lly polished, and made ready for the next process—tempering. This is ... placing the pens, a few at a time, on a stove, heated to the proper tem-...; so soon as a bright blue colour is obtained they are removed, this ... denoting the temper best suited to steel pens. The last operation is that ... ing the slits, or, as some call it, *cracking* the slits; this singular process ... by placing about a quarter of an inch of the pen's point between a ... small nippers, and pinching them suddenly, when the slit, which was ... two-thirds of the way through, is completed by the giving way of the ... of the metal. This unique process fits the pen for immediate use; ... manufacturers add a coat of lacker, but this is not of much real ...

... often been supposed that other materials would be equally, if not more, ... than steel, for the manufacturing of pens; those persons who have paid ... ention to the subject, however, are decidedly of opinion that no kind of ... however fine its texture may be, or whatever properties it may possess, ... be able to compete with fine well-tempered steel.

... of the steel pens, as now manufactured, we find of excellent quality; ... ndred pages of this work have been written with *one* pen, in a uniform ... d. After writing with it about forty pages, we usually renew, and ... improve the nibs of a new pen by a few touches of a dry Turkey ... ding the sight with a pair of magnifying spectacles, in order that the ... the extreme end may be duly perfected; this process will, however, be ... difficult of accomplishment, at first, by persons unaccustomed to the point-... delicate instruments, and, at the present low prices of the article, scarcely ... the trouble; but the ability to perform this operation at pleasure upon ..., renders a person very independent of the stationer's shop.

In our brief account of this novel and admirable manufacture, we are sensible of having omitted to notice a variety of excellent steel pens, but our allotted space compels us to proceed to the description of a different class.

Fountain Pens. A great number of ingenious attempts have been made to construct pens containing a reservoir of ink, which, by a slight pressure on the handle, or other part, might cause a fresh supply of the fluid to flow to the nibs, and thus supersede the necessity of an ink-stand. Of this kind is the *penograph* of Mr. Scheffer, manufactured by Messrs. Mordan & Co., in which the pressure of the thumb on a projecting stud in the holder causes a continuous supply of ink from the reservoir to flow into the pen.

Mr. Parker's *Hydraulic Pen* is a more recent contrivance for the same purpose. In this machine a piston is made to work up and down in a cylindrical tube by means of a revolving nut acting upon the piston rod, which is tapped with a corresponding screw. The small orifice at the bottom of the holder being immersed in ink, the turning of the upper portion of the holder causes the piston to ascend, and the tube becomes filled with ink; on gradually turning the nut in the opposite direction, the piston descends and forces the ink down into the pen. Mr. Parker has taken out a patent for his invention, but, if we mistake not, Mr. W. Baddeley proposed an apparatus, precisely similar, a long time since; for which see the *Mechanics' Magazine*.

As a description of all the contrivances of this kind, however, would occupy many pages, we shall limit our account to one of a very simple and unexpensive kind, the invention of a correspondent of the *Register of Arts*. "The pen is made of two quills; the top one, which I shall call No. 1, and the other, No. 2. Let the end of No. 1 be made air-tight, by dropping inside, to the bottom, a small piece of cobbler's wax, and then warming it a little: fill this nearly with ink,—say about a quarter of an inch from the brim,—then take a small piece of cambric and cover the top of it, so that the ink may not drop out; join both quills together, by putting No. 1 into No. 2, and the pen is ready for use. When you want to write, take the pen in your right hand, give a gentle shock on your left hand, or on a table, and the ink will run down into the pen immediately; this must be repeated every time ink is wanted. A pen of this kind will be found very useful to reporters and to persons travelling. The pen should be put into a little case to carry it about."

Pens (*drawing*).—By this term is commonly understood the mechanical drawing-pens, consisting of a pair of delicately-formed steel blades, the ends of which are drawn together and adjusted by means of a fine set-screw; these pens are mounted with handles of various materials, but those of ivory or ebony are deservedly preferred. These instruments are manufactured by Mr. Elliott, of High Holborn, in the highest perfection. The extremities of the steel blades which form the pen should be very narrow ellipses, and should perfectly meet without the minutest projection of one piece over the other. The outside of the elliptical end should be rubbed on a hone until it is as thin as the edge of a knife: in this state the points would cut the paper; but the sharpness must be taken off by gently drawing them over the stone upon their edges, and finishing them upon a soft polishing-stone. A smoothness is thus given to their edges which makes them glide over the paper, although they will still be left so thin that their edges can scarcely be discerned. By this management, lines may be drawn while the points of the pen are at a distance from each other, not perceptibly exceeding the breadth of the lines produced, which is of consequence, not only to the equable flow of so viscid a fluid as Indian ink, but to obtaining a well defined stroke.

A drawing-pen was lately presented to the Society of Arts, by Mr. Bryan [illegible], which he had brought from France. It is calculated to make lines of one uniform thickness: the cavity which contains the ink being enclosed all round, keeps it free from dust, and prevents it from drying, and clogging the drawing point so quickly as those of the ordinary construction. *Fig.* 1 (in the following page) shows the pen, with the handle broken off; *a* and *b* are the two blades, jointed at *c*, and held close by the sliding ring *d*; the dotted lines [illegible] portion *a* as opened, to receive the ink, with the ring *d*

beyond the joint. *Fig.* 2 shows the underside of the limb *a*, in a ... at *c* is the hole to receive the centre-pin; *e* is the cavity for

Fig. 1.

Fig. 2

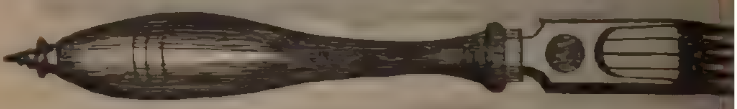
..., notches for receiving two projecting pieces, as shown at *f* in

...ly simple and ingenious mode of making a drawing- ...-mentioned kind (that is, to make a line of only one ... as invented by Mr. Robert Christie; and having ... according to his instructions, which answer very well ... it moves with equal facility in any direction, we ... of it in this place. The annexed cut represents ... pens, in a neatly-turned handle; but we made them ... of black-lead pencils, for the convenience of readily ... lead or ink. The process, as directed by Mr. Christie, ...—A piece of sealing-wax, about the size of a mar- ... to be stuck upon the end of the pencil, by melting it, ... by a bulb, into which are to be inserted three darning- ...arming their eyes in the flame of a candle, and then ... in the wax, at equal distances apart, around the ... of the pencil, with their points extending about ... of an inch beyond the end of it; but brought ... to meet as accurately as possible at a common ... the outline of a triangular pyramid: to secure them, ... of wax, about the size of a grain of wheat, is to be ... between the bulb and the points, and secured there ... The very acute points of the needles are to be taken ...lling touches upon an oil-stone, and the raggedness, ... emery-paper, so as to produce an obtuse, conical end; ... thus completed, has of course a very fine triangular ... the needle-points, through which the ink uniformly ... have seen some of these pens made by inserting the ... drilled holes, made in metal, at the end of neat ... which the needles were so nearly brought together ... inserted, as not to need the smaller bulb nearest ... The ink flows freely in them, and there is the ... in using them as a finely-pointed H H H black-lead ... answer well for tracing, as before observed; but we ... them equal to the common forceps-formed drawing- ... clear lines.

... for common use, are made by doubling a piece of ...ber, and rounding the ends, the middle being bellied ...on of ink. Pens of this description were constantly ...ing account-books, &c., previous to the introduction ...-machine, which entirely superseded hand-ruling.

Ruling-pens for the machine are made of thin sheet-brass or latten, in long strips, the pens being cut on the edge, and folded together at various distances, according to the pattern to be executed.

Music-pens are made for ruling the five staves of music at once; they consist of a parallelogram of brass, terminating in five slit points, communicating with a small reservoir above, in which the ink is placed. They are fitted with a handle, in the hollow of which a small piece of brass is carried for cleaning out the ink passages of the pen. The accompanying engraving shows the construction of this very useful and ingenious apparatus.



Dotting-pens, for writing music, consist of a small brass cylinder, in which a pin of the same material works vertically, being kept down, and projecting about the tenth of an inch, by a spiral spring in the upper part of the pen. An elliptical opening, about halfway up the pen, receives the ink. When placed upon the paper, the brass pin recedes, and causes the ink to make a round black spot on the paper, forming a note,—the tail being supplied afterwards with a common pen.

PENCIL. An instrument used by painters for laying on their colours; they are of various kinds. The larger sorts are made of bears' bristles, the thick ends of which are bound to a stick, large or small, according to the use they are designed for; these, when large, are termed brushes. The finer sorts of pencils are made of camels' hair, also badgers' and squirrels' hair, and of the down of swans; these are tied at the ends by a piece of thread to keep the hair from spreading, and the other ends are enclosed in the barrels of quills of various sizes, suited to the pencil, some of which are of small birds, as those used for drawing lines, and in miniature painting. The usual test of a good pencil is to draw it between the lips, when it should come out with a sharp conical, and, as it were, solid point.

Pencil is also an instrument used for drawing and writing, made of long slips of black-lead, chalk, or crayon, placed in a groove made in the centre of a stick of wood, usually cedar, on account of the facility of cutting it. The very common black-lead pencils that are hawked about are a composition of powdered black-lead and melted sulphur. Their melting, or softening, or yielding a bluish flame, on application to the flame of a candle, betrays their composition. The genuine black-lead pencils are made of the fine Cumberland plumbago, sawed into slips, fitted into the grooves, and having another piece glued over them. The pure plumbago is, it is said, too soft to enable an artist to make a fine line; to produce this effect, a hard resinous matter is intimately combined with the lead in the following way, which is said to be the invention of Mr. Cornelius Varley. Fine Cumberland lead, in powder, and shell-lac are first melted together by a gentle heat. This compound is then reduced to powder again and re-melted; then powdered again and re-melted, until both substances are perfectly incorporated, and it has acquired a perfectly uniform consistence. The mass is then sawed into slips, and glued into the cedar mountings in the usual manner of making other black-lead pencils. To render them of various degrees of hardness, the materials are differently proportioned; the hardest having the most shell-lac, the softer but very little, and the softest none, and their blackness is increased in proportion to their softness.

Mordan's "ever-pointed pencils" were the subject of a patent granted to Hawkins & Mordan, in 1823. The pencil-case has a slider, actuated by a screw for the purpose of projecting forward a little cylinder of black-lead, as it wears away, which is done by holding the nozzle in one hand, and turning round the pencil-case with the other, the thickness of the lead being so small as not

cutting for the ordinary purposes of a pocket-pencil. *Fig* 1 is
of the pencil-case; A the black-lead or crayon, encompassed by the
which, with the whole of the case, is made of metal, usually silver. B
river, being a hollow cylinder with a screw-thread round a part of it;

nd of this screw the black-lead is inserted and held fast; C is the elon-
art of the driver, which passes through the guide D; at E, within the
se, is another cylindrical piece, connected to the nozzle at one end, and
the other a hollow screw that works round on the thread of the
, and, as it turns, causes the projector to advance or recede, as may be
. These pencil-cases have had an immense sale, and have been improved
a variety of ways during the last ten years.
DULUM. A vibrating lever or suspended weight. See HOROLOGY.
STOCK. A sluice or floodgate, serving to retain or let go at pleasure
r of a mill-pond.
PER. A well-known spice, of which there are three kinds,—the *black*,
, and the *long* pepper; to these we may now add a fourth, *bleached*
a patent process which the black pepper undergoes in this country to
white.
pepper is cultivated with such success at Malacca, Java, and especially
tra, that from these islands pepper is exported to every part of the
here a regular commerce has been established. The ground chosen for
garden is marked out into regular squares of six feet, the intended
of the plants, of which there are usually a thousand in each garden.
per vines are supported by chinkareens, which are cuttings of a tree of
e planted on purpose. Two pepper vines are usually planted to one
n, round which the vines twist for support. After being suffered to
three years, they are cut off about three feet from the ground, and,
ened from the prop, are bent into the earth in such a manner that the
d is returned to the root. The fruit, which is produced in long spikes, is
ve months in coming to maturity: the berries are at first green, turn
ht red when ripe and in perfection, and soon fall off if not gathered in
e. By drying they become black, and more or less shrivelled, according
degree of maturity.
mmon white pepper is the fruit of the same plant, differently prepared.
ped in water, and then exposed to the heat of the sun for several days,
nd or outer bark loosens; it is then taken out, and when it is half
ed till the rind falls off; and the white fruit remaining is dried in the
great deal of the heat of the pepper is taken off by this process, so that
kind is more fit for many purposes than the black.
ong pepper is a dried fruit, of an inch or an inch and a half in length, and
thickness of a large goose-quill; it is of a brownish grey colour, cylin-
figure, and said to be produced on a plant of the same genus. It is a
the East Indies, especially Java, Malabar, and Bengal. This fruit is
o the taste in its immature state, and is therefore gathered while green,
d by the heat of the sun, when it changes to a blackish or dark grey
Dr. Cullen observes, that long pepper has precisely the same qualities
se of black, but in a weaker degree.
method of preparing the bleached pepper appears to be engrossed by
on, of London, who has taken out two patents, one in 1828, the other
By the specification of the first we are informed that the common
pper is steeped in water for a day or two, then laid in heaps, and occa-

sionally turned; fermentation ensues, and in a space of time, varying from a week to a month, the outer or black skin bursts and falls off. The pepper is then bleached by oxymuriate of lime, sulphur, or other well-known means. This done, it is washed, and lastly dried in the air, or in an oven. Black pepper thus metamorphosed, so exactly resembles, it is said, the genuine white pepper as to deceive experienced dealers. In the second patent, Mr. Fulton's claim seems to be in the inverse ratio of his invention; for he has invented, he says, the application of a common groat or barley-mill to the cleansing of pepper from the husks, and he claims the exclusive right to use all sorts of machinery in preparing pepper.

The public should be upon their guard against the quantities of spurious pepper, both whole and ground: the latter is, of course, easily counterfeited, but the manufacture of the former is somewhat ingenious. The pepper dust from the sweepings of warehouses is mixed with oil-cake, and rolled up into little balls resembling pepper.

PERCUSSION, *Centre of*, in any body or system of bodies revolving about a point or axis, is that point which, striking an immovable object, the whole mass shall not incline to either side, but rest in equilibrio without acting on the centre of suspension. If a person attempt to strike any object with a straight stick, and do not strike it in the centre of percussion, a considerable jarring will occur, which will not be felt if the blow be given in that point. In a straight stick of equal thickness, the centre of percussion is two-thirds of the length of the stick from the axis of motion. Generally, the distance of the centre of percussion from the centre of motion is equal to the sum of the products of each particle of the body, by the square of its distance, divided by the product of the whole mass by the distance of its centre of gravity from the axis of motion.

PERCUSSION POWDER. Take two parts of the chlorate of potash, and one of antimony; they must be separately levigated to an impalpable powder in a marble mortar, and mixed together with an ivory knife; to granulate it, it must be made into a thick paste, with spirits of wine, in which must be dissolved a little gum mastic to make it adhesive; and, by forcing it through a hair sieve it will be formed into grains. Four parts of potash, and one of antimony, will detonate; but this mixture was found, after a great number of trials by an eminent chemist, not to be sufficiently strong to be depended upon. See Detonating Powders.

PERPETUAL MOTION is that which possesses within itself the principle of motion; and, consequently, since every body in nature, when in motion would continue in that state, every motion once begun would be perpetual but for the operation of some external causes; such as those of friction, resistance, &c.; and since it is also a known principle in mechanics, that no absolute power can be gained by any combination of machinery, except there being, at the same time, an equal gain in an opposite direction; but that, on the contrary, there must necessarily be some lost from the above causes, it follows that a perpetual motion can never take place from any purely mechanical combination; yet this is a problem which has engaged the attention of many ingenious men from the earliest period to the present time, though it has but seldom been attempted by men of science since the true laws of mechanics have been so well established.

PERSIAN WHEEL. See Hydraulic Machines.

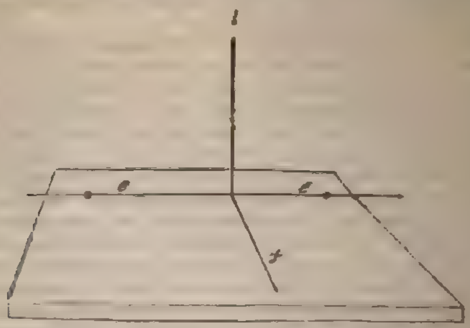
PERSPECTIVE. The art of delineating objects on any given surface as they would appear to the eye if that surface were transparent, and the objects themselves were seen through it from a fixed situation. Thus, if on looking through a window at any object we were to trace over all the lines of the object on the glass, carefully keeping the eye in precisely the same position all the time, we should make a perspective drawing of the object, and the glass would be termed the plane of delineation. Every true perspective picture is, therefore, an exact copy of the order in which the rays, proceeding from the object represented, would intercept in their passage to the eye a transparent plane at right angles to the direction in which the eye viewed that object.

is the plane of delineation of the picture, which is large or small, to its distance from the eye. It does not form a part of the plan of to give a treatise on the art of drawing in perspective; and the observations have been chiefly made as introductory to the next

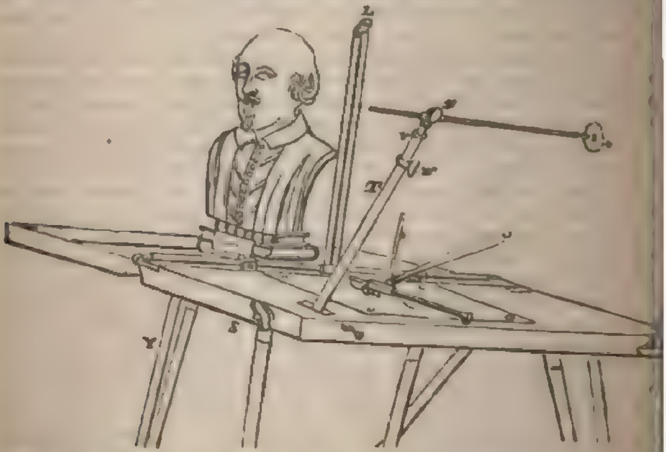
CTIVE INSTRUMENTS. A mechanical contrivance designed the making of drawings in perspective, especially by such persons acquainted with the rules by which it is performed. Some of these are on optical principles, such as the camera obscura, and the lucida, already noticed under their proper heads. In praise of the has been lately said, and although it must be admitted to be a very beautiful instrument, the acquisition of the art of using it is difficult to all, and to some persons impossible. Its chief use will be ding the means of contemplating the real perspective appearance and perhaps to obtain the position of a few points, but for very ation it is of little value. One of the simplest mechanical contri- aking successively on the perspective plane the various *points* of an dscape, and marking them down on paper with accuracy, was long ed by Ferguson, to whom the knowledge of it was communicated . It consisted of an oblong rectangular board, across the middle was attached by hinges a movable frame, the sides of which were two equal circular arcs, that met together at the top in the man- thic arch. To the centre of each of these arcs was attached a cord, ds of which were fastened to sliding pieces traversing their respec- these cords therefore crossed each other, and by moving the slides to the opposite arcs, the cords might be made to intersect each other in the plane, or space between the arcs. The eye-piece, or hole ich the object to be drawn is viewed, is fixed to a slide in the centre of the board, and the distance between the eye and the plane of may be thus varied to increase or diminish the size of the picture. f of the board between the frame, (when the same is turned upright .) and the object viewed, the paper to be drawn upon is pinned will now, we think, be plain, that to mark down the exact position in a picture, it is only necessary to move the slides so that the intersect at that point; having thus found it, the arched frame is down upon its hinges flat upon the board or paper thereon, a mark e on the latter at the point of intersection of the cords. Suppose us made indicates the extremity of the parapet of a building, the then moved so as to intersect the cords at the other extremity, that found, and the frame again turned down to mark it; then by con- e two points on the paper by a line, the precise inclination and per- asurement is infallibly correct, and by proceeding to work in this the outlines of an entire picture may be accurately laid down. truments have been contrived for finding the various perspective the process, it must be allowed, is extremely slow; even the most e would require to have many points found in it before its outline aced; and if it consisted of curved or irregular lines, many more be taken in each curve to get a correct delineation.

onalds, of Croydon, has, however, contrived and patented an appa- hich *the lines themselves, of whatever form or arrangement they may drawn directly from the object* with the same facility as tracing them. on simply consists in causing a small bead to traverse in the plane on, but the bead cannot make any movement whatever without a anically attached to it, which traces down on paper, lines precisely ng with the figure; in other words, while the bead traverses over the object, the pencil moving with it does of necessity make an spective drawing. *Fig.* 2, in the following page, gives a perspective of the forms of the complete instrument in the manner it is used, the legs on which it stands are cut off to save space. But in the reader may easily comprehend its action, we subjoin the annexed

diagram, illustrative of the principle. The instrument consists of a
bar *e e*, moving horizontally on two rollers attached to the table; *f l*
other bars fixed at right angles to the bar *e e*, and to each other, the



lying on the drawing paper (horizontally), the latter placed perpendicul
the plane of the picture, all being attached together: if the bar *f* be mo
the right or left, the vertical rod *l* will slide on the rollers in a vertical pl
the plane of delineation. To the bar *f* is adapted a slider with a pencil,
in *Fig.* 2; to this pencil a silk thread is fastened, which passes under a p



the corner where all the bars meet; thence it proceeds upwards, parallel
bar *l*, (at which part it carries the small bead,) and finally passes over a
at the top, having a little weight which falls down the bar or tube *l* atta
other end.

It will now be evident, that if we move the slider with the pencil
horizontal bar, the weight attached to it by means of the silk thread m
fall through an equal space, and with it the bead placed upon
whether the pencil be moved to the right or left, or along the bar *f*, th
move in the same direction, but in a plane at right angles to it.
these two motions, it follows that every combination of them,
curved or straight lines, must be similarly performed both by the be

using the instrument, it is requisite to arrange the sight-hole, attac

(through which alone the operator must use his eye in sketching,) ...ition of the bead on the thread, so as to get the drawing within the ...e drawing paper. The handle which is attached to the slider with ...by an universal joint, must now be moved about, causing the bead to ...r every line of the object, which, being marked down by the pencil, ...fac-simile of the motions of the bead on the plane of delineation. ...n this most ingenious instrument a simple and elegant adaptation of ...on laws of the science of perspective; it may be called a teacher ...tive as well as a perspectograph. These instruments are constructed ...sizes, and packed in cases, including a book of instructions, at very ...harges. They are manufactured by Messrs. Holtzapfell, of Charing ...he best style of workmanship.

...FACTIONS. Stony matters deposited either in the way of incrusta-...thin the cavities of organized substances, are called petrifactions. ...earth being universally diffused, and capable of solution in water, ...s, or by the medium of carbonic acid or sulphuric acid, which are ...ry abundant, is deposited whenever the water or the acid becomes ... Incrustations of limestone or of selenite, in the form of stalactites, ...tes, are formed in this way, from the roofs of caverns, and in various ...ations. Some remarkable observations relating to petrifactions are ...by Kirwan:—

...those of shells are found on or near the surface of the earth; those ...per, and those of wood deepest. Shells in specie are found in im-...ntities at considerable depths.

...those organic substances that resist putrefaction most are frequently ...fied, such as shells and the harder species of woods: on the con-...e that are aptest to putrefy are rarely found petrified, as fish, and the ...s of animals, &c.

...they are most commonly found in strata of marl, chalk, limestone, ...dom in sandstone, still more rarely in gypsum, but never in gneiss, ...salts, or shorl; but they sometimes occur among pyrites, and ores ...pper, and silver, and almost always consist of that species of earth, ...her mineral that surrounds them, sometimes of silex, agate, or car-...

...they are found in climates where their originals could not have ...

...those found in slate or clay are compressed and flattened.

...LEUM. A fluid bitumen, of somewhat greater consistence than ...f a black, brown, or sometimes dingy green colour. By exposure to ...ssumes the consistence of tar, and is then called *mineral tar*. This ...xudes spontaneously from the earth, or from clefts of rocks, and is ...dly in all countries. Near Rangoon, in Pegu, there are several ...wells of petroleum, which are carefully preserved, and yield annually ...gsheads. At Colebrook-dale, in Shropshire, there is a considerable ...etroleum, from which large iron pipes are employed to convey it into ...o receive it. From these pits it is conveyed into caldrons, in which ...until it attains the consistence of pitch. Since the first discovery of ...ace, three different springs of it have broken out: one of these is ...lebrated iron bridge, and the fluid which issues from it is almost ...s, at the same time, thicker than treacle. Petroleum easily takes ...burning yields a strong, sharp, and somewhat unpleasant odour; a ...disagreeable smoke. In cold weather it congeals in the open air. ...instead of oil for lamps in some places; also, when combined with ...ters, in painting timber, and is supposed to check and prevent the ...ges of the worm upon the bottoms of ships coated with it.

...R, which is commonly called *étain* in France, and generally con-...ae with true tin, is a compound metal, the basis of which is tin. ...rt consists of tin, alloyed with about a twentieth or less of copper, or ...lic bodies, as the experience of the workmen has shown to be the most ...o the improvement of its hardness and colour, such as lead, zinc,

bismuth, and antimony. There are three sorts of pewter, distinguished by names of plate, trifle, and ley-pewter. The first was formerly much used plates and dishes; of the second are made the pints, quarts, and other measures of beer; and of the ley-pewter, wine measures, and large vessels. The sorts of pewter consist of 17 parts of antimony to 100 parts of tin; but French add a little copper to this kind of pewter. A very fine silver-looking metal is composed of 100 pounds of tin, 8 of antimony, one of bismuth, four of copper. On the contrary, the ley-pewter, by comparing its specific gravity with those of the mixture of tin and lead, must contain more than a fifth part of its weight of lead.

PHANTASMAGORIA. The exhibition called by this name is performed by means of a magic lantern, constructed on a large scale. In the common magic lantern the figures are painted on the glass, and all the rest of the glass is transparent; but in the phantasmagoria the whole of the glass is made opaque, except the space taken up by the figures painted with the transparent colours, hence this difference in the effect is produced, that no light falls upon the screen but what passes through the figures themselves, consequently there is no circle of light, nor any thing but the figures on the screen. Let the door of a dark room in which the exhibition is to be seen be set wide open, and its place supplied with a screen of thin silk, or fine linen, or of paper rendered transparent. From the outside of the room let the pictures, painted as above described, be thrown upon the screen, of a very minute size. They will immediately be seen within the room, and, though remarkably brilliant, they will be supposed to be distant by the spectators, because they see nothing but the light which comes from them. If the lantern be drawn back to a greater distance from the screen, the images become gradually enlarged, and appear to approach the spectators, and seem pendant in the air.

PHARMACY. The art of preparing, compounding, and preserving medicines. The established and authorized modes of practising this important art are to be found in those books called pharmacopœias.

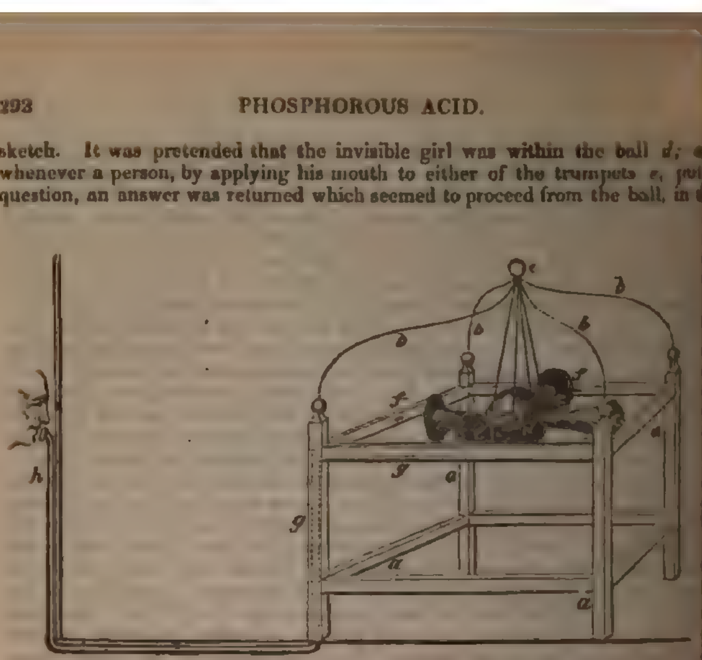
PHAROS. A name sometimes given to a lighthouse, from the circumstance of the first being built at Pharos, near Alexandria. See Lighthouse.

PHONICS, or Acoustics. A science which treats of the nature and mode of propagation of sound. Whenever any elastic body is made to vibrate, it produces corresponding vibrations in the air surrounding it; these acting on the ear, cause its internal parts to vibrate and excite in us the sensation of sound. From the necessity of air to the conveyance of sound in ordinary experiments, the phenomena of sound have usually been considered as forming part of the science of Pneumatics; but the entire difference of its results, and its connexion with elastic bodies generally, sufficiently justify its claim to a separate denomination. That sound cannot be conveyed from one part of space to another without some material connexion, is well ascertained, and may, to a certain extent, be proved, by suspending a bell within a glass receiver of an air pump, and exhausting the air; it will then be found that as the air is withdrawn, the sound of the bell becomes more and more feeble, so that, at last, it is scarcely audible. That air is not the only conductor of sound may be shown by various experiments. If a heavy mass of iron, as a kitchen poker, be suspended by a piece of twine, the two ends of which are pressed against the ears, and the poker be then struck against any metallic substance, as a fender, a sound will be heard of so great intensity as to resemble the tolling of a bell. If two stones are struck against each other under water, the sound may be heard at a great distance by plunging the head beneath the surface of the water: Dr. Franklin affirms that he has heard it in this way at the distance of half a mile. Sounds are also transmitted to great distances through solid bodies. If a slight scratch be made at one end of a long piece of timber, and the ear be applied to the other, a distinct sound will be heard. In this manner miners hear the sounds made of their fellow-workmen, and thus judge of their direction. If a person be placed at one end of a series of metallic tubes, the blows of a hammer at one extremity are heard distinctly at the other, two sounds being heard, one conducted by the air, and the other by the metal. To show

really the effect of vibrations in the bounding body, carried to a certain f rapidity, a long string, or wire, may be stretched by a small weight; tions at first will be distinctly seen, and may be counted; but in this produce no perceptible sound. If the weight which extends the cord sed, the vibrations become more rapid, and a sound is heard which more acute as the string is more stretched.

umber of experiments it has been found that sound travels through th a velocity of about 1140 feet in a second, or nearly 13 miles in a The velocity with which sound travels may be easily proved by a periment. Let a gun be fired at a given instant, and let a person a known distance, observe the time elapsed before he hears the report, will determine the time the sound has been travelling over the given By knowing the velocity with which sound travels, we may ascertain nce of a thunder-cloud, or of a ship in distress. Suppose the light n fired at a distance, or from a flash of lightning to be observed at a ant, and that five seconds elapse between seeing the flash and hearing t; then since the motion of light may be considered as instantaneous, of seeing the flash may be taken as the instant at which the sound sets as it travels 1142 feet in a second, the space passed over in five ll be $1142 + 5 = 5710$ feet, or 1 mile and 430 feet, which will be the of the object from which the sound proceeds. According to Dr. Young, the velocity of sound, on an average, is 1130 feet. The sound , or of a hammer, is equally swift in its motion; the softest whisper ftly as the loudest thunder. The equal velocity of the different tones ifully shown by Biot in experiments on the pipes of the aqueducts at distance of about 3000 feet; an air was played on a flute at one extre- listened to at the other end, and the time was perfectly preserved; the equal velocity of the various notes was demonstrated. Different transmit sound with different velocities. If the velocity in air be ed by 1, the velocity in rain-water will be $4\frac{1}{3}$, in sea-water $4\frac{7}{10}$, and in . The velocity of sound is uniform. The strength of sounds is n cold and dense air, and least in that which is warm and rarefied. int against which the pulses of sound strike becomes a centre, from new series of pulses is propagated in every direction. Sounds may be like light, and thus form what is termed an echo. For the most echo the sounding body should be in one focus of the ellipse, which is of the echoing spheroid, and the hearer in the other. An echo may, be heard in other situations, though not so distinctly. Thus a person s the echo of his own voice; but for this purpose he should stand at 64 feet from the reflecting obstacle. At the common rate of speaking, ance about seven syllables in a second; in order, therefore, that the return just as soon as three syllables are expressed, twice the distance aker from the reflecting surface must be equal to 1000 feet; for as cribes 1142 feet in a second, six-sevenths of that space, that is, 1000 y, will be described, while six, half, or three whole syllables are pro- ; that is, the speaker must stand nearly 500 feet from the obstacle. In e distance of the speaker from the echoing surface for any number of must be equal to the seventh part of the product of 1142 feet multi- that number. When the walls of a passage, or of an unfurnished e smooth and perfectly parallel, any explosion, or a stamping with the municates an impression to the air, which is reflected from one wall er, and from the second to the ear, by which reverberation the primi- d is greatly increased in intensity. Sound, like light, may be reflected eral places, and collected in one point as into a focus, and it will be e audible than at the place from whence it proceeded. On this prin- whispering gallery is constructed, the form of which must be that of hemisphere. Somewhat similar is the effect of speaking and hearing which, by reverberating the sounds uttered through them, increase nsity. By means of an arrangement of these, a deceptive acoustic s was exhibited, an idea of which may be formed by the following

sketch. It was pretended that the invisible girl was within the ball *d*; and whenever a person, by applying his mouth to either of the trumpets *e*, put a question, an answer was returned which seemed to proceed from the ball, in the



centre of which the invisible being was supposed to reside. A reference to the cut will explain the manner in which the illusion was accomplished. The upper part of the frame-work is hollow; and by means of the tube *g g*, passing through the leg of the apparatus and floor of the room into another chamber, communicates with another individual *h*, who is to represent the invisible girl. When a person is desirous of trying the experiment, he applies his mouth to either of the trumpet-mouths *e e e e*, and puts his question; the sound thus uttered is reflected so as to pass through the holes *f f*, and through the pipe *g* to *h*, where it is heard by the person who is then listening. A reply is then given through the tube *h g g*, which, coming out through the hole *f*, is received in the trumpet-mouths, and reflected to the ear of the inquirer at *e*. The trumpets being suspended by silken strings, no visible connexion appears between the place whence the sound seems to proceed, and the individual who is the author of it; the illusion is therefore complete.

PHOSPHATES. Salts formed by the phosphoric acid with the alkalies, earths, and metallic oxides. The phosphates at present known amount to twelve, two of which are triple ones.

PHOSPHITES. Salts formed with the phosphorous acid united to the earths, alkalies, and metallic oxides.

PHOSPHORIC ACID. The base of this acid, or the acid itself, abounds in the mineral, vegetable, and animal kingdoms. In the mineral kingdom it is found in combination with lead in the green lead ore; with iron in the bog ores, which afford cold-short iron; and more especially with calcareous earth in several kinds of stone. Whole mountains in the province of Estramadura, in Spain, are composed of this combination of phosphoric acid and lime. In the animal kingdom it is found in almost every part of the bodies of animals which are not considerably volatile: there is not, in all probability, any part of these organized beings which is free from it. It has been obtained from blood, flesh, both of land and water animals; from cheese; and it exists in large quantity in bones, combined in calcareous earth. Urine contains it not only in a disengaged state, but also combined with ammonia.

PHOSPHOROUS ACID is prepared by exposing phosphorus during some weeks to the ordinary temperature of the atmosphere. Even in winter the phosphorus undergoes a slow combustion, and is gradually changed into

For this purpose it is usual to put small pieces of phosphorus on ... of a glass funnel, through which the liquor that is formed ... bottle placed to receive it. From an ounce of phosphorus about ... of acid liquor may be thus prepared.

...RUS. A substance which shines by its own light. The dis... singular substance was accidentally made in 1677, by an alchemist ... named Brandt, when he was engaged in searching for the philo... Mr. Boyle is also considered to have discovered it; he commu... process to Godfrey Hankwitz, an apothecary of London, who, for ... supplied Europe with phosphorus; and hence it went under the ...glish phosphorus. In the year 1774 the Swedish chemists, Gahn ... made the important discovery, that phosphorus is contained in the ...mals; and they improved the process for procuring it. The most ...cess for obtaining it seems to be that recommended by Fourcroy ..., which we shall transcribe. Take a quantity of burnt bones, ...em to powder: put 100 parts of this powder into a porcelain or ...in, and dilute it with four times its weight of water; 40 parts of ... are then to be added in small portions, taking care to stir the ... the addition of every portion. A violent effervescence takes ...reat quantity of air is disengaged. Let the mixture remain for ...urs, stirring it occasionally to expose every part of the powder to ...e acid. The burnt bones consist of the phosphoric acid and lime; ...ric acid has a greater affinity for the lime than the phosphoric acid. ... the sulphuric uniting with the lime, and the separation of the ...d, occasion the effervescence. The sulphuric acid and the lime ...her, being insoluble, and fall to the bottom. Pour the whole ... cloth filter, so that the liquid part, which is to be received in a ...l, may pass through. A white powder, which is the insoluble ...me, remains on the filter. After this has been repeatedly washed ... may be thrown away; but the water is to be added to that part ...which passed through the filter. Take a solution of sugar of lead ... pour it gradually into the liquid in the porcelain basin; a white ... the bottom, and the sugar of lead must be added so long as any ...akes place. The whole is to be again poured upon a filter, and ...der which remains is to be well washed and dried: the dried ... to be mixed with one-sixth of its weight of charcoal powder. ...ture into an earthenware retort, and place it in a sand bath, with ...nged into a vessel of water; apply heat, and let it be gradually ... the retort becomes red hot. As the heat increases, air-bubbles ...ance through the beak of the retort, some of which are inflamed ...me in contact with the air at the surface of the water. A sub... drops out similar to melted wax, which congeals under the water; ...orus. To have it quite pure, melt it in warm water, and strain it ... through a piece of chamois leather, under the surface of the ...ould it into sticks, take a glass funnel with a long tube, which ...ed with a cork; fill it with water and put the phosphorus into it: ... funnel in boiling water, and when the phosphorus is melted and ... tube of the funnel, then plunge it into cold water; and when the ...has become solid, remove the cork and push the phosphorus from ...th a piece of wood. Thus prepared, it must be preserved in close ...ining pure water. When phosphorus is perfectly pure it is semi... and has the consistence of wax: it is so soft that it may be cut ... Its specific gravity is from 1.77 to 2.03. It has an acid and ...taste, and a peculiar smell, somewhat resembling garlic. When a ...phorus is broken, it exhibits some appearance of crystallization. ...re needle-shaped, or long octahedrons; but to obtain them in their ...state, the surface of the phosphorus, just when it becomes solid, ...reed, that the internal liquid phosphorus may flow out, and leave ...eir formation. When the phosphorus is exposed to the light it ... reddish colour, which appears to be an incipient combustion. It

is therefore necessary to preserve it in a dark place. At the temperature of 90° it becomes liquid; and if air be entirely excluded, it evaporates at 219°, and boils at 554°; at the temperature of 43° or 44° it gives out a white smoke, and is luminous in the dark; this is a slow combustion of the phosphorus, which becomes more rapid as the temperature is raised. When phosphorus is heated to the temperature of 148°, it takes fire, burns with a bright flame, and sends out a great quantity of white smoke. Phosphorus enters into combination with oxygen, azote, hydrogen, and carbon; it is soluble in oils, and, when thus dissolved, forms what has been called liquid phosphorus, which may be rubbed on the face and hands without injury; it dissolves, too, in ether, and a very beautiful experiment consists in pouring this phosphoric ether in small portions, and in a dark place, on the surface of hot water. The phosphoric matches consist of phosphorus, extremely dry, minutely divided, and perhaps a little oxygenated. The simplest mode of making them is to put a little phosphorus, dried by blotting-paper, into a small phial; heat the phial, and when the phosphorus is melted, turn it round, so that the phosphorus may adhere to the sides. Cork the phial closely, and it is prepared. On putting a common sulphur-match into a bottle, and stirring it about, the phosphorus will adhere to the match, and will take fire when brought into the air.

PHOSPHURETS. Substances formed by an union of the alkalies, earths, and metallic oxides, with phosphorus. Thus we have phosphuret of lime.

PHOTOMETER. An instrument designed to exhibit the different quantities of light, especially in bodies illuminated in different degrees. In Leslie's photometer, the essential part is a glass tube, like a reversed syphon, whose two branches should be equal in height, and terminated by balls of equal diameter: one of the balls is of black enamel, and the other of common glass, into which is put some sulphuric acid, tinged with carmine. The motion of the liquid is measured by means of a graduated scale; the zero is situated towards the top of the branch that is terminated by the enamelled ball. The use of the instrument is founded upon the principle, that when the light is absorbed by a body, it produces a heat proportional to the quantity of absorption. When the instrument is exposed to the solar rays, those rays that are absorbed by the dark colour heat the interior air, which causes the liquor to descend at first with rapidity in the corresponding branch. But as a part of the liquor which has introduced itself by means of the absorption is dissipated by radiation, and as the difference between the quantity of the heat lost and that of the heat acquired goes on diminishing, there will be a point where (these two points having become equal) the instrument will be stationary, and the intensity of the incident light is then estimated by the number of degrees which the liquor has run over.

Mr. Ritchie, of Nain, has constructed a very simple photometer, on the principle of Bougier. It consists of a rectangular box, about an inch and a half or two inches square, open at both ends, and blackened within for the purpose of absorbing irregular light. Two rectangular pieces of plain mirror are placed within the box, at right angles with each other, and at an angle of 45° with the sides of the box. A rectangular opening is cut in the upper side or lid of the box, about an inch long and an eighth broad, and, passing over the line formed by the intersection of the two mirrors, is half over the one and half over the other; the aperture is to be covered with a slip of fine tissue, or oiled paper. When used, it is to be placed in the same straight line, between the two flames to be compared, they being distant six or eight feet from each other, and is to be moved until the disc of paper is equally illuminated by the two flames. The illuminating powers of the two flames will then be directly as the squares of their distances from the middle of the photometer. In viewing the illuminated disc, it is well to look at it through a prismatic box, about eight inches long, blackened within, to absorb strong light. Sometimes, instead of using mirrors and the paper-screen, the

lanes are covered with white paper, and looked at directly through ire. However the instrument be used, a mean of several observations taken, the instrument being turned round each time. When the of different colours, the plan Mr. Ritchie recommends is, to cover the opening in the instrument with a piece of fine white paper, printed with a small type; the paper is to be brushed over with oil, and then the being placed between the lights, they are to be moved till the printing continuously along the paper with equal ease on the one side as on the the second form, the printed paper is to be pasted on the mirrors, or surfaces against which they lie, and is then to be read through the It is advantageous to enlarge the openings in these applications of per.

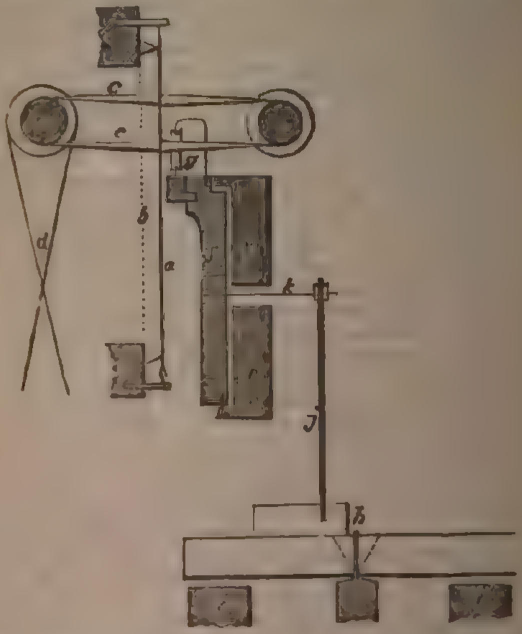
-FORTE. A musical instrument, resembling the harpsichord, (of an improvement,) in which the tone is produced by hammers, instead upon the strings. Of all the keyed instruments, as observed in the *yclopædia*, the piano-forte seems to merit the preference, on account erior tone, sweetness, and variety, of which, by the ingenuity of ists, it has now become susceptible. It was, as early as the beginning century, that hammer-harpsicords were invented at Florence, of is a description in the *Giornale d'Italia*, 1711. The invention made progress; the first that was brought to England was by Father Wood, monk at Rome. The tone of this instrument was so superior to that y quills, with the additional power of producing all the shades of forte by the finger, that though the touch and mechanism were t that nothing quick could be executed upon it, yet the Dead March d other solemn and pathetic strains, when executed with taste and a master a little accustomed to the touch, excited equal wonder and he hearers. Backers, a harpsichord-maker, constructed several piano- although he improved the mechanism in several respects, he failed After the arrival of John C. Bach in this country, and the esta- of his concert, in conjunction with Abel, all the harpsichord-makers mechanical powers upon piano-fortes; but the first attempts were the large size, till Zumpé, a German, constructed small piano-fortes, e and size of the original, of which the tone was very sweet, and the a little use, equal to any degree of rapidity. Pohlman, whose in- were very inferior in tone, fabricated a great number for such persons was unable to supply. Large piano-fortes afterwards received great nts in the mechanism by Merlin, and, in the tone, by Broadwood, Clementi, and others. The harsh scratching of the quills of a d can now no longer be borne. A great number of improvements made of late years, which have been the subjects of numerous Some of these we now proceed to notice.

which presents itself to our attention is the patented improvement heatstone, of Jermyn-street, for augmenting the tone by the introduc- ms, or similar vibrating surfaces, against which the sounds elicited ; these, it is said, not only augment the tone, but improve the For this purpose, wooden frames are fitted to the inside of the instru- which is tightly stretched paper, parchment, vellum, or similar which constitute the drum. These, being placed as near as possible nding-boards of the instruments, are powerfully acted upon by the of the notes given out; and to conduct the sound elicited with greater he ears of the auditory, trumpet-shaped apertures are made through of the instruments.

o piano-fortes the rich and lengthened tones of the violin, a patent out by Mr. Todd. This is effected by the pressure of the foot of the n a pedal, which puts in motion an endless band (furnished with resin), which is made to rub against the particular wire in connexion y that is depressed by the finger of the player; and thus the same oduced as by the bow over the strings of the violin. Instruments ed will therefore have two distinct sets of tones; that is, when the

pedal is acted upon, the lengthened and beautiful tones of the violin are produced; without it, those of the ordinary piano.

The invention is not, however, confined to piano-fortes, but to all instruments wherein the sounds are produced by the vibration of wire strings of catgut; but the most eligible instrument for its application, is the piano, more especially those of the upright or cabinet kind. The annexed diagram we have therefore selected from the specification, to explain the construction and modes of action of this ingenious contrivance, when applied to piano-fortes of the latter description. The figure gives a vertical section of a part; thus *a* shows one of the wires stretched across the bridges, by means of tension pins over the body of the instrument. *c c* is an endless band revolving



over two cylinders, which are set in motion by the treadle *d*, operated upon by the pedal; this band is to be made of cloth, catgut, or other material capable of holding powdered rosin. *e e* is a frame of wood on which is made to turn the swinging piece *f*, and there are as many of these frames and swinging pieces as there are keys to the instrument. On each swinging piece are fixed wires, bent in the manner shown; their ends are reduced to a conical figure to form centres, upon which revolve small brass rollers, as that at *g*. *h* is one of the keys of the instrument moving on its fulcrum pin, and its two stops are shown; a vertical stem of wood *j* is fixed into the key, carrying above it, in a horizontal position, a wire *k*, which acts upon the swinging piece *f*; the wire *k* is fixed to the stem *j* by means of nuts placed on either side of the stem, which screw on to the end of the wire, and by these means the extent of motion to be given to the swinging piece is regulated. It will now be seen that when any key is depressed by the finger of the player, the little brass roller *g* is pressed against the endless band, which, bending it a little out of the right line, causes it to rub against the wire *a*, and thereby produce a similar effect to the drawing of the bow over the strings of a violin.

[...]vention which we shall notice is that of Mr. James Stewart, of [...] Euston-square, who had a patent for it in 1830. It will be [...] there are several motions connected with the operations of a piano [...] great precision as to their time, duration, and intensity of action. [...]must be made to strike the string at the same instant that the damper [...] and the hammer having done its duty must be instantly removed [...]he finger of the performer has left the key,) from the string, to [...]tion to take place, and then the damper must return to stop the [...]le string the moment that the finger is withdrawn from the key. [...]e motions must be obtained by a very slight touch of the finger, [...]ny noise, the levers and connecting rods, by which they are trans[...]the keys to the strings, become important considerations with [...]kers, and Mr. Stewart has simplified the action, and rendered it [...]by the introduction of a short lever placed over, and parallel with [...]d of the finger lever. This lever being short, and joined near its [...]by a small connecting brass rod to the finger lever, furnishes in [...]ired variety of motions, by placing the rods which act upon the [...]per, &c. at different distances from the fulcrum on which it turns. [...] this, Mr. Stewart has introduced an improved inclined plane for [...]tail of the hammer, and stopping it silently, after it has struck the [...]

[...]the objections which have been raised to the elevated casing of the [...]net piano-fortes, especially those whose fronts are covered with [...]ve a tendency to deaden the voice in case of accompaniment, [...]hompson, of Yarmouth, has contrived to obviate the necessity of [...] the instrument rising above the locking board, so that the top of [...]t is flat like a table. This object he effects by lowering the string [...]pper surface coincides with the top of the locking board, and [...]ys bent levers, turning twice at right angles between the fulcrum [...]move, and the extremities which act upon the hammers. On [...]s of each key, rests an upright guide wire, or slight rod, and [...]ched various projecting pieces which actuate the hammers, the [...]uch in the usual manner; so that this improvement, which is a very [...], is obtained without in the smallest degree altering the other [...]strument.

[...]f improvement in this interesting branch of art seems recently to [...]rvaded our transatlantic brethren. In the *Journal of the Franklin* [...]h contains accounts of all the American patents,) we observe one [...]Thompson, of New York, dated October, 1830, for an improvement [...]f the upright piano-forte, some points in which our own manu[...] deem worthy of adoption in a modified form. The following claim [...]e specification of this patent, will give to those acquainted with [...]eneral idea of the variations introduced in this action. "What [...], and as my own invention, is, first, the application of the finger [...]to the foot of the connecting rod, dispensing with the jack, springs, [...]ediate gearing. By this more immediate operation of the finger [...]r, no time is lost between the touch and the blow; the action is [...]ble by the finger; the blow is quicker, and more powerful; the [...]ever block; it relieves less from the string, and requires much [...]uch. The simplicity of its construction renders the work much [...]ss liable to get out of order, than any known action. From this [...]he action, I have been able to render the span of the natural [...]d a half inches, and the others in proportion, without in any [...]ing with a clear and rapid execution: or the common span of [...]y be retained. Second, the placing the dampers below the [...]by which position the dampers fall on the brass strings near the [...], and thus more instantaneously and effectually stop their vibra[...] be raised by the simpler and cheaper modes herein specified."

[...]ction of cast iron into the framing of piano-fortes, in lieu of the [...]es of wood previously used, to resist the powerful tension of so [...]s a great modern improvement, to which we believe we stand

indebted to M. Pleyel and Co., of Paris. At the present time the substi
of metal for wood is general.

This part of the mechanism was considerably improved by Mr. J. C. Schw
of Regent-street, for which he obtained a patent in 1831. The string boa
the piano-forte is secured between a stout cast iron frame, and to the latt
cast a projecting plate, through which the tuning pins pass. These tuning
are made of steel, their lower ends are turned cylindrical, for coiling the en
the wire, and the upper ends are made square for the reception of the key
give these tightening pins the requisite friction to retain any required de
of tension on the strings, and enable them to be turned with facility, they
tapped below the square head to receive a nut, which screws against the u
side of the projecting plate, and they have underneath a collar and washer, w
are drawn against the plate by the action of the nut above, leather washers
also interposed to give a degree of elasticity to the bearing parts. To produc
requisite friction, the nuts are screwed up; and in order that the pins ma
turned at pleasure, without altering the friction by which they are held, each
is perforated with two holes, and the square key which fits over the square h
has at its extremity two projecting pins, which enter the holes in the
and therefore turn the pins and nuts together without altering the fric
Mr. Schwieso applies tightening pins of this kind to the harp and violin.

Since the introduction of cast-iron frames for piano-fortes, consider
expense has been incurred in drilling the holes for, and fitting in the pins
us to give them the properties mentioned in Mr. Schwieso's patent. To re
these inconveniences, Mr. W. Allen, of Catherine-street, Strand, casts two d
tailed grooves along that end of the frame where the tightening pins are
inserted, into which he drives pieces of wood of a corresponding shape,
up the dovetailed grooves, and to receive the tuning pins. It is evident, th
this ingenious and simple contrivance, the expense of manufacture wi
diminished, and the instruments will be improved.

Self-acting Piano-fortes have of late years been introduced: they combin
most rapid and brilliant execution with distinctness and neatness. Their
mony is necessarily more full than can be produced by eight fingers, the ele
of chords having no other limit than the extent of its scale; the time ca
be otherwise than perfectly equable throughout, yet where pathos is
expressed, the time can be accelerated or retarded in any degree.

The mechanism of a self-acting piano-forte usually or principally consi
a cylinder turning horizontally on its axis, acted upon by a coiled spring,
regulated by a fly-wheel. On the surface of the cylinder, a determined arr
ment of brass pins is formed, each of which, in passing under a rank of le
elevates one end of the required lever, and depresses the other. The depr
end pulls down with it a slender rod, which is connected by a slide with th
of a bent lever, on the further end of which is the hammer which strike
string. The slide can be shifted further from, or nearer to the axis, on whic
hammer lever turns, and thus the stroke of the hammer is made feeble or s
to any required degree. When wound up, the instrument will continue to
for a considerable time; and it is provided with a bench of keys like the
nary piano-forte, so that a person may accompany the instrument, or
duet with it.

A very beautiful instrument of this kind we have seen, that was man
tured by Clementi and Co.; it had two barrels, each of which played nine
The velocity was regulated by two revolving balls, similar to the governor
steam-engine.

Messrs. Rolfe and Sons, of Cheapside, have distinguished themselves in
branch of art by several improvements, which were the subject of a recent p
These improvements they divide into three sections; and their self-acting p
fortes are constructed either with the first section only, or with the first and se
section combined, or with the three sections united. The first section consist
new apparatus for effecting the transitions of *forte* and *piano*, by which me
difficulty of producing those desirable changes is removed, by transferring
mechanical action from the weakest and most uncertain part of the arrange
viz. the cylinder, to the more powerful and certain action of the engine, by w

he liability to derangement in instruments intended for exportation is . To this branch of their patent, Messrs. Rolfe and Sons have annexed ovement, or register, by which the existing arrangement, or distribu- *rte* and *piano*, may at any time be changed, or altered to suit particular may at any moment be removed from the government of the self- paratus which produces the effect, and be operated upon by the hand, be restored to the control of the machine, at pleasure.

econd section consists of a new barrel movement for changing the tunes, effected by the introduction of an inclined plane, which forms an t for the axis of the cylinder. This plane is divided into eight portions, oved by a radial lever upon a pinion, which by its rotation one revolu- es upon a second dial an index to the extent of one eighth of its cir- ce, moving the inclined plane to a proportionate extent. By this rangement the motions are rendered very steady and accurate, and inct airs may thus be performed.

ird section consists in the application of a set of dampers to the self- ng action, which are altogether independent of the dampers; so that of the self-acting or mechanical part of the instrument, in common particular note of the finger action, possesses its appropriate damper, with and identified by its kindred note, hammers, or keys, and acting ously therewith. In conjunction with the application of the mecha- pers, suitable staples are introduced into the cylinders, which, acting particular damper as occasion may require, suspends its operation, and hem to retain the vibration of any given note, or the root and relative of harmonious combinations, in the same manner as the finger of a sustains the vibration of chords, whose existence is to be prolonged ued pressure of the keys, according to the duration expressed by the ed value given to them by the author in the composition performed. on to this, the whole set of mechanical dampers are occasionally raised linder, according to circumstances, in order to produce the effect, or , of the open pedal when moved by the foot of the performer.

. A strong erection jutting into the sea, for affording shelter to and small craft, or for the convenience of landing goods and pas- For the former purpose they are usually constructed of very massive ble materials, wrought together in the most solid manner; such as stones, dovetailed into each other, and cramped with iron, being sup- the outside by large piles driven into the ground, and strongly framed by several rows of cross pieces. A rocky point is generally chosen (if ained) for joining the pier to the land; the other end is extended out , either in a right line or a curve, but more generally the latter, to nclosed harbour for shipping within the curve. Breakwaters are more in straight lines; chain-piers are also straight, as that at Brighton: ruction of these is precisely similar to suspension bridges. See BRIDGE.

S, *of a Bridge*. The walls or masses from which the arches spring.

S, *in Building and Architecture*. The wall interposed between two also the buttresses or masses of wall raised to strengthen buildings.

-ENGINE. A machine for driving piles into the ground, to make a dation for buildings, the construction of piers, wharfs, &c. As these e of every-day observation, and are figured in all previous works of , we shall confine ourselves to a brief verbal description. By means chanism of a common crane, a heavy iron weight, called the *ram*, is pendicularly between two lofty guides of timber, framed together at d laterally, clear of the ram. Just as the ram attains to its highest a projecting lever from the hook to which the ram is suspended meets d obstruction to its upward passage, that bends the lever downwards, unhooks the ram, which, falling from a great height, strikes the head with tremendous force, driving it into the ground. The hook and descend, and the hook, coming in contact with the top of the ram, f thereto again by means of a spring or lever-catch, when it is drawn o repeat the operation.

PIN. A well-known little instrument, chiefly used to adjust or fasten the clothes of women and children. Although consisting of merely a piece of wire, with a head and a point, great mechanical ingenuity has been exercised to perfect its construction at a cheap rate; but such is the extent of the consumption, and consequent importance of the manufacture of pins, that there are many establishments where upwards of two tons, containing about 20,000,000 in number, are made weekly. The *ordinary* method of making pins has been thus described by various authors on the subject. Brass wire, drawn to the required size, is straightened by drawing it between steel pins, set in a zigzag form upon a bench, and afterwards cut into such lengths as will each make six pins of the required size. These lengths are pointed at the ends by boys, who sit each with two small grindstones before him, turned by a wheel. Taking up a handful, he applies the wires to the coarsest of the two stones, moving them round at the same time, and in such a position as to produce evenly-rounded and well-tapered conical points, which are perfected and sharpened by him afterwards upon the smoother stone. A lad of twelve years of age will thus point 16,000 in an hour. The length of a pin is then cut off each end of the pointed wire, and the remaining portion of wire is treated in a similar manner, successively, until the six pins of each length have been pointed. The next operation is heading, or rather "head-spinning;" the heads being prepared for subsequent putting on, by winding a finer wire around another wire of the size of the pin, by the rapid revolution of a kind of spinning-wheel. The internal wire being drawn out leaves the external wire of the form of a tube of circumvolutions; this tube is cut into short lengths, of only two circumvolutions, each of which forms one head; these are made red-hot in an iron pan, over a furnace, to soften them, that they may not spring under the hammer in fixing them on. These annealed heads are distributed to children, who sit with little anvils and hammers, the latter being worked by means of the feet upon treadles. Taking up a pin, they thrust its blunt end amongst a quantity of the head-spinnings; and, catching up one, they apply it immediately to the anvil, and, by means of two or three blows of the hammer, compress the head firmly upon the end of the wire, with remarkable dexterity. The several motions of the little operator succeed each other so rapidly that it requires the closest observation of the process, many times repeated, to enable a stranger to perceive how it is performed. The pins have now to be whitened, which is effected by putting them in a solution of tin in the tartaric acid. Here they remain until they have acquired an extremely thin coat of the tin, which presents, when withdrawn from the bath, but a dull appearance: the pins are therefore thrown with some bran into a barrel, which, being in revolution upon its axis, the bran thus rubs the pins quite bright; they are then taken out, and the bran separated from them by a winnowing machine. Machines have, however, been recently constructed in which a coil of wire is converted into pins without any manual intervention or any extraneous assistance whatever.

PINCHBECK, or PRINCE'S METAL. An alloy of copper, much resembling gold in colour. It consists of one part zinc to five or six parts of copper.

PINION, in *Mechanics*, a small-toothed wheel, which drives, or is driven by a larger.

PINNACE. A small vessel, navigated with oars and sails, and having generally two masts, which are rigged like those of a schooner. One of the boats belonging to a man-of-war, for carrying the officers to and from the shore is called the pinnace.

PIPE. A cask containing from 110 to 140 gallons of wine; the Madeira pipes containing about 110, and the Port and Lisbon from 138 to 140 gallons.

PIPES, for the conveyance of water and other liquids, are made of lead, iron, stone, pottery, wood, Indian-rubber, &c. Of iron there are two sorts,—wrought and cast.

Wrought-iron pipes are made out of plates of the required thickness, length and breadth; so that when coiled into a circular form, the edges may lap over each other. To make sound, good work of this kind requires great address and

pidity of execution in the welding operation; so that the ordinary smith seldom attempts it, preferring to purchase the article, or get it made by the regular tube-makers. The manufacture of wrought-iron tubes has lately, with considerable success, been effected by machinery, under a patent granted to Mr. Whitehouse (for Mr. Russel), of Wednesbury. The sides of the metal being bent up with swages, so as to bring the edges nearly together, he introduces the tubes so prepared into a furnace, and, when brought to a welding heat, to the operation of a small tilt-hammer: the face of the hammer, as well as that of the anvil, have semi-cylindrical grooves, corresponding with the size and shape of the tubes under manufacture; and between these the tube is gradually passed along, receiving in its progress a rapid succession of blows from the hammer. When the welding is thus completed, the tubes are in a rough state; they are therefore again heated in the furnace, and passed between large grooved rollers, which give to the tubes a smooth exterior surface; as they emerge from the pressure thus given, they come in contact with a fixed round rod of the proper size of the bore of the tubes or pipes, over which they are forced by the rollers; and thus the interior as well as the exterior are brought to a smooth and true cylindrical surface.

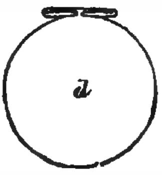
Cast-iron pipes, of which immense quantities are used for the conveyance of gas, water, and other fluids, are made in the following manner. The mould for casting is thus prepared: strong cast-iron flanged cylinders, about three feet long, and having an internal diameter greater than the outside of the intended pipe. These cylinders divide longitudinally into halves, which are secured together by iron cramps; in this state one of them is placed upright upon a firm foundation, underneath the jib of a crane, to which is suspended a smooth cylindrical mandril; this mandril is then lowered perpendicularly into the centre of the cylindrical mould until it rests in a hole in the stand at the bottom, and leaves around the mandril a void space of equal dimensions, in which position it is secured by wedging pieces at the top. Sand duly prepared and moistened is then put into the void space by degrees, until it is filled, ramming it down at intervals, to render it equally solid throughout. The smooth mandril is then carefully drawn out by the crane, and the sand-charged cylinder is removed to the drying stove. Other cylinders are similarly charged, and dried in the stove. To make the core, the moulder takes a quadrangular bar of iron, about a foot longer than the intended pipe, wraps it along with a hay-band, and inserts it centrically into a pipe smooth in the inside, of the length, and of the same internal diameter as the required pipe; a mixture of sand loom, hair, &c. is then rammed between the cylinder, and is thus forced amongst the fibrous matter around the bar, to which it firmly adheres when drawn out of the smooth-bored cylinder, the core thus produced being dried in the stove, is ready for the casting. As the length of cast-iron pipes for water is usually nine feet, three of the before-mentioned cylindrical sand-boxes are put into requisition for the purpose, they are placed one upon the other upright in a pit, and connected together by cotters through their flanges. The sand and loam core before mentioned, is now carefully lowered from a jib into the centre of the combined sand boxes, which is insured by a projecting piece of the iron bar entering a socket at the bottom, and the upper end is secured by a collar of clay. The space now left between the core and the cylinder of sand is now filled with melted metal through an orifice in the clay at top, by means of a ladle, charged from the tap hole of the furnace, which is carried and poured into the mould by the casters, if not too heavy; but if so, this carriage is assisted by a truck or dray, and the ladle or pot discharged by the aid of pulley tackle. When the mould is cooled, it is hoisted by the crane altogether from the pit; the sand cases are taken off, the iron rod withdrawn, and the pipe being cleared of the sand inside and out, is ready for clearing, examination, and use. In the casting of very large cylinders, a similar process is adopted, except that the metal is allowed to flow directly from the furnace, along a trench into the mould.

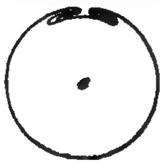
Hancock's patent Pipes.—A patent was taken out in 1826 by Mr. Walter Hancock, of Stratford, in Essex, for the manufacture of water or other pipes,

that should be as durable, but less expensive, than the cast-iron pipes we h been just describing; and as the manufacture of these may be advantageou conducted in situations where the products of a foundry cannot easily be p cured, we annex the ingenious process of the patentee.

Sheets or strips of iron or copper are selected of the appropriate lengt breadths, and thicknesses, for making the proposed pipes. In making a cyl drical pipe, the sheet must be of greater width than the circumference requir and of a true rectangular figure. Each of the two opposite edges are then be doubled or folded back, as shown by the annexed figure *a*. The sheet

then to be bent round by the ordinary means into a cylindrical form, and t edges turned back as shown in the annexed *Fig. b*. A slip of sheet iron, of the same thickness and length as the before-mentioned, with parallel sides, is then doubled back at the edges in the same manner as shown at *c*; this piece is then slided over the ends of *b*, so that the edges of both shall mutually envelope and brace each other, in the manner exhibited in the following *Fig. d*; the joints thus made are then brought into close contact by hammering. This method of joining the tubes may with equal facility be effected on the inside, if in turning the sheet up into the cylindrical shape it be bent the reverse way, as shown in *Fig. e*. The proje ing part of the joint being inside, is preferable in many cases. The tube, now described, the patentee calls his *inner* tube, to distinguish it from t





exterior covering it afterwards receives, to increase its strength and durabil This is effected by winding round the inner tubes iron hoops, or narrow st of metal, rivetted end to end in a spiral direction, with the coils in close cont generally, but sometimes a little apart, to give them elasticity in bending. T operation is performed by fixing the tube upon a wooden roller, of a diame nearly corresponding with the internal diameter of the said tube, and the ro is mounted horizontally upon an iron axle in a fixed frame, with a handle turning it round at one or both ends. One of the ends of the hoop iron is th made fast to the end of the tube by a rivet, and being held in an oblique p tion with the axis of the roller, the latter is turned round, while sufficient t sion is given to the hoop iron to make it lie close and tight to the tube dur the coiling operation; after which it is fastened to the other end of the t by another rivet. A hoop or ring is now put on *hot*, to each end of the t at right angles with the axis, for the greater security of the previous bindi these end hoops, as they cool, contract in their circumference, and conseque fix themselves, and bind all the parts of the tube firmly together.

The tubes are next to be immersed in liquid cement, contained in a vesse suitable capacity to receive them; the cement is thus made to enter and fill every fissure or interstice between the several parts of the tubes. The cem is composed of the following ingredients and proportions, mixed and me together: viz. 2 lbs. bees' wax, 2½ lbs. linseed oil, 12 lbs. common white re 18 lbs. pitch, 1 lb. tallow, and 16 lbs. of plaster of Paris, or Roman cement

quicklime in powder; and when it is desired to give a greater degree of elasticity and toughness to the cement, 2 lbs. of Indian rubber, previously dissolved in five quarts of oil of turpentine, are to be added.

To protect the outside of the pipes from rust, one or more layers of canvas, saturated with the cement, are to be wrapped round it. In lieu of this, sometimes the patentees put a tube of sheet iron for the external covering, and fill up the interstices between with cement.

In order to connect such pipes together, a tube, similar to those already described, is prepared, of a length somewhat more than its diameter, which should be about three quarters of an inch greater than the diameter of the tubes to be connected; the latter being placed end to end, with the piece of connecting tube extending equally over each, and the annular space between the tubes are filled in with cement. To prevent the cement from getting in between the two opposed ends of the tubes, they are previously brought into contact, and covered at the point of junction, with a pley or two of oakum. At each end of the connecting tube is fixed a wooden ring, and the annulus thus rendered uniform is filled with the cement, in a hot and liquid state, by an iron syringe inserted in a hole made in the connecting tube. Instead of iron, the patentee makes use of wood sometimes for his inner tubes; these are composed of a number of pieces laid longitudinally side by side, and arranged in a circle. This tube is put upon a wooden cylinder, similar to the before-mentioned, and being turned round, it is covered spirally with iron hoops. For large sized tubes, wood is preferable, as being stiffer and stronger than those made of sheet iron of moderate thickness. The wooden tubes, bound in iron, are completed by similar processes to those described in the other kind.

Bagshaw's patent earthen pipes are thus made:—Chlindrical plugs of wood, of the same diameter as the bore of the intended pipe, and of the same length, are coated with a sufficient thickness of clay, or plastic earth, which has been duly prepared in the manner practised in the potteries. To perfect the exterior form of the pipe, an external mould is to be employed, consisting of two semi-cylindrical pieces, which are to be placed on each side of the intended pipe, when the edges are to be brought together by screwing them up, which will press out the superfluous clay from the mould; the exterior mould being next removed, the pipe will be found completely formed upon the plug: in this state it is to be dried; after which the plug may be easily withdrawn, and the pipes finished, by baking them in an oven. The pipes are to be connected together by inserting the smaller end of one into the larger end of another, and filling up the interstices between them with Roman or other soft fluid cement. Pipes produced in a similar manner, of which the material was a *cement or imitation stone*, have likewise been brought into use.

Some years since Mr. Murdock took out a patent for the economical fabrication of *pipes of real stone*, the process combining the advantage of making solid cylinders at the same time. In forming a pipe or hollow cylinder of stone, instead of cutting out in useless scraps, or grinding to powder, the whole diameter of the bore, the patentee cuts out a core or solid cylinder, whose outside diameter is only about half an inch less than the inside diameter of the pipe. In like manner, when he intends to form a column or solid cylinder, or disc of stone, instead of breaking off, cutting, or chiseling away the superfluous parts of the stone, these parts are formed into a hollow cylinder, the core of which is the solid cylinder or disc required. Hence, if the stone is large enough to leave the outside parts of a proper thickness, these parts may be used as a pipe, and the core may either be used as a solid cylinder or column; or, by a further operation, it may be converted into a pipe, and the cylinder cut out of it may again be converted into another pipe, which process may be continued until the core cut out is too small to be useful. The following is the mode adopted by the patentee of accomplishing it:—he fixes the block of stone to be perforated in an upright position, and in the centre of the top of the block of stone, a step to receive the toe of a vertical spindle, which derives its motion from a pulley turning in plummer-blocks in a fixed frame above; this axis is considerably longer than the pipe or column to be formed, having the faculty

of sliding vertically through the aforesaid horizontal pulley, over which it is suspended by a rope that passes round a vertical pulley, and thence is connected to a winch to wind up the axis at pleasure. The saw employed is at the edge of a hollow cylinder (on the same plan as that described by us for trepanning under the article ANNULAR SAW), and this hollow cylinder is turned by the spindle through the medium of cross-arms, through which the axis slides; and in order to give the requisite force to the annular saw, the top of the tube to which it is fixed is loaded, provided its own weight be insufficient: the motion given to the saw, though circular, is reciprocating. To effect this, a rope passes round the pulley at the upper part of the axis, and the two ends of the rope are conducted in opposite directions over two vertical pulleys, over which the two ends of the rope respectively fall, where they are each furnished with a cross handle; one workman takes hold of one handle, and another workman the other, and pulling alternately the pulley at the top of the axis, together with the annular saw, is made to reciprocate circularly, cutting an annular groove in the block of stone. A barrel of sand and water is made to deliver these essential auxiliaries to the saw in the following manner:—it is directed to the upper end of the axis above the tube, which it enters, and runs down into the annular groove under the edge of the saw, whence it flows upward by the pressure of the continued descending current on the opposite side, and thus carries off the sludge clear of the saw. Stone tubes of this kind were employed by the Manchester Water Works Company.

Elastic tubes of Indian rubber are extensively used for the transmission of gas and corrosive liquids; and they are admirably manufactured by Mr. Thomas Hancock, of Goswell-street Road. Mr. Thomas Skidmore, an American gentleman, whose process is a good one, is as follows:—Take a cylindrical rod of iron of the desired length, round this closely coil annealed wire in the manner of a spiral spring, care being taken that the edges of the coiled wire shall touch each other, but shall, at the same time, not be so firmly wound as to prevent its slipping off the rod: then cover the wire with tape spirally from end to end, and upon it lay strips of Indian rubber, wound in a similar manner, with their fresh cut and clean edges lapping upon each other. Then bind these down tightly with another coil of tape: after this withdraw the rod, and boil the tube in water for an hour or two; when cool, remove the wire and tapes, and a Indian rubber tube will be produced, which, though rough, will be perfectly sound if the process has been properly conducted.

The method of making *leaden pipes* has been described under the article LEAD; but we will take the opportunity of mentioning in this place, that it appears by some recent experiments made by Mr. Jardine, of the Water Company's Works at Edinburgh, that a lead pipe of 1¼ inch bore, and the fifth of an inch in thickness, was found capable of sustaining a power equal to that of a column of water 1000 feet high, which is equal to 30 atmospheres, or 420 pounds per square inch of internal surface. With a pressure of 1200 feet it began to swell, and at with 1400 feet it burst. In another experiment, a pipe two inches in diameter, and one-fifth of an inch thick, sustained 800, but burst with 1000 feet pressure.

Wooden pipes for the conveyance of water, are bored by means of large iron augers, worked by one or two men, who commence with a small bore, and increase it as the work proceeds, by changing the auger to a larger size, which are sometimes extended to eight or nine inches in diameter. The tree in the process of boring, is laid horizontally upon tressels constructed to support and hold it firmly, and the augurs are similarly supported and guided, so as to pass centrically through the tree. The manual operation is of course slow, and extremely laborious: machinery, worked by steam, or other power, has therefore been introduced to execute the work. The piece of timber, or tree, is held down upon a frame by chains passing over it, and round two windlasses. The frame and tree, thus bound together, run upon small wheels traversing two long beams, called ground-sills, placed on each side of a pit, dug to receive the chips made by the borers. At one end they are connected by a cross-beam, bolted upon them; this supports the bearing for a shaft, the extremity of which, beyond the

bearing, is perforated at the end of a square hole to receive the end of the borer. The timber and carriage are made to advance towards the borer by means of ropes; one rope being made to wind up, while the other gives out and draws the carriage and piece of timber backwards and forwards according as the wheel is turned. The weight of the borer is supported by a wheel turning between uprights fixed on a block, the end of which rests upon the ground-sills: it is moved forward by means of two iron bars, pinned to the front cross-bar of the carriage. The distance between the wheel and the carriage may be varied by altering the iron bars and pins, so as to bring the wheel always as near as convenient to the end of the tree. The shaft may be turned by any first mover. When the borer is put in motion by turning the wheel, he draws the tree up to the borer that pierces it; when a few inches are bored, he draws the tree back by reversing the motion of the wheel, in order that the borer may throw out its chips; he then returns the tree, and continues the process until the work is finished: the borer, in this case, be its size what it may, is of the same shape as that of a common auger. We would suggest the employment of spiral augers instead of the common, as the former would deliver the chips as it proceeded, and not require withdrawal until the perforation was completed.

Some years ago Mr. Howel, of Oswestry, invented a machine for making concentric wooden pipes out of one piece of timber, the mechanism of which was on the same principle as that we have described under Mr. Murdock's patent for sawing out stone pipes, who, it appears, derived the principle of operating from Mr. Howel, and modified it so as to adapt it to the cutting of stone.

Tobacco-pipes.—The clay of which these are made is obtained from Purbeck, in Dorsetshire, and at Teignmouth, in Devonshire, in large lumps, which are purified by dissolving in water in large pits, where the solution is well stirred up, by which the stones and coarse matter are deposited; the clayey solution is then poured off into another, where it subsides and deposits the clay. The water, when clear, is drawn off, and the clay at the bottom is left sufficiently fit for use. Thus prepared, the clay is spread on a board, and beaten with an iron bar to temper and mix it; then it is divided into pieces of the proper sizes to form a tobacco-pipe; each of these pieces is rolled under the hand into a long roll, with a bulb at one end to form the bowl; and in this state they are laid up in parcels for a day or two, until they become sufficiently dry for moulding, which is the next process, and is conducted in the following manner:—The roll of clay is put between two iron moulds, each of which is impressed with the figure of one-half of the pipe; before these are brought together a piece of wire of the size of the bore is inserted midway between them; they are then forced together in a press by means of a screw upon a bench. A lever is next depressed, by which a tool enters the bulb at the end, and compresses it into the form of a bowl; and the wire in the pipe is afterwards thrust backwards and forwards to carry the tube perfectly through into the bowl. The press is then opened by turning back the screw, and the mould taken out. A knife is next thrust into a cleft of the mould left for the purpose, to cut the end of the bowl smooth and flat; the wire is carefully withdrawn, and the pipe taken out of the mould. The pipes, when so far completed, are laid by two or three days, properly arranged, to let the air have access to all their parts, till they become dry; when they are dressed with scrapers to take off the impressions of the marks of the moulds; they are afterwards smoothed and polished with a piece of hard wood.

The next process is that of baking or burning; and this is performed in a furnace of a peculiar construction. It is built within a cylinder of brickwork, having a dome at top, and a chimney rising from it to a considerable height, to increase the draught. Within this is a lining of fire-brick, having a fireplace at the bottom of it. The pot which contains the pipes is formed of broken pieces of pipes cemented together by fresh clay, and hardened by burning; it has a number of vertical flues surrounding it, conducting the flame from the fire-place up to the dome, and through a hole in the dome into the chimney

Within the pot several projecting rings are made; and upon these the bowls of the pipes are supported, the ends resting upon circular pieces of pottery, which stand on small loose pillars, rising up in the centre. By this arrangement a small pot or crucible can be made to contain fifty gross of pipes without the risk of damaging any of them. The pipes are put into the pot at one side, when the crucible is open; but when filled, this orifice is made up with broken pipes and fresh clay. At first the fire is but gentle, but it is increased by degrees to the proper temperature, and so continued for seven or eight hours, when it is damped, and suffered to cool gradually; and when cold, the pipes are taken out ready for sale.

PISTON. That part in a steam engine on which the elastic force of the steam exerting itself puts it into motion; and which, through the medium of the piston rod connected thereto, actuates the entire machine. The term piston is likewise sometimes employed to designate what is more generally termed the "bucket" of a pump. There is no part of the steam engine in which correct principles of construction and accurate workmanship are so essential. If the sides of the piston which rub against the cylinder or steam-way do not touch in every part, the steam escapes, power is lost, and fuel is wasted. If the piston rubs hard in one place, and softly in another, the cylinder becomes unequally worn, and its utility impaired or destroyed. To obviate these difficulties, therefore, the rubbing surfaces of a piston should not only be made as uniform as possible, but also elastic, in order that it may expand and fill up all inequalities of surface with a gentle pressure. The usual mode of effecting this object is represented in the subjoined section of a common piston for a low pressure engine; *a* is the lower face of the piston made of metal, to which is fixed the piston rod *b*, that passes through the top plate *c*, which is made fast to the lower by screws *d d*; at *e e* is the packing (as it is termed,) made of hemp, saturated with tallow, which is wound and bound round the annular cavity made between the plates *a* and *c*; this elastic packing, as it wears away by friction against the cylinder, is occasionally screwed up, by turning the screws *d d*, which forces it out against the sides of the cylinder; and when entirely reduced, it is renewed by repacking with fresh materials. From want of due care and skill in this kind of packing a great loss of power in an engine is often sustained, either by the steam passing the piston, or by its being squeezed so tight as to cause great friction, and soon wear itself out. If the steam of an engine be weak, and the packing of the piston press tightly against the cylinder, the whole, or nearly the whole of the power may be expended in giving it motion, especially in cylinders of small diameter. On the contrary, if the packing presses very weakly against the cylinder, and the steam be very strong, the steam will push the packing away and pass to the other side of the piston; and it should be borne in mind, that when this happens, it is not only the loss of the steam, but the reaction which it exerts on the other side, neutralizing an amount of force equal to its own volume. For these reasons, it becomes obvious that pistons should possess another property, that of being tight in proportion to the force of the steam which presses upon them. Several plans have been proposed to construct pistons on that principle, amongst which are the following, proposed by a correspondent in a periodical journal in 1823, which perhaps deserve notice, as furnishing useful hints to the practical man.

Fig. 1.

In the annexed *Fig.* 1, A A is a metal plate *sliding* upon the piston rod; D D is the solid part of the piston, connected with the plate by a band *n n*; the space C C is to be filled with oil or other oleaginous fluid. By this arrangement it will be evident that the greater the force of the steam, or other pressure, upon the surface

...tes, the more closely will the packing be pressed against the sides of ...der.

...nexed *Fig.* 2 is a variation from the last; the ...ottom plates are fixed, and the steam acts ...t bolts or plungers *b b*, which, by being pressed ...force out the packing at the sides. *Fig.* 3 ... a mode of applying the principle to metallic ... A A is a metallic plate sliding on the piston ...made in the form marked by the dark line. ...e metallic rings of a triangular form, divided ...ing joint: D D is the solid part. The pres... the steam will cause the plates to descend, ...essing upon the inclined planes of the rings, ... causes them to expand, and adhere to the ...the cylinder; a small space is left between ...part and the plates, to allow for the descent ...er, but in no way so great as represented; ... being only designed by the inventor to show ...iple, and not the details of construction. ...cked with hemp and tallow continued in ...very little variation, from the time of Captain ...that of Dr. Cartwright, a period of ninety-nine years. That scientific ... had, however, the honour of first introducing, in an ingenious engine ... construction, an expanding or elastic piston made entirely of metal,— ...on of indispensable utility in all engines working at high pressure.

Fig. 2.

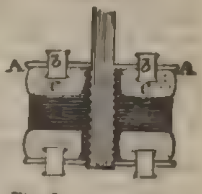
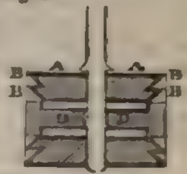


Fig. 3.

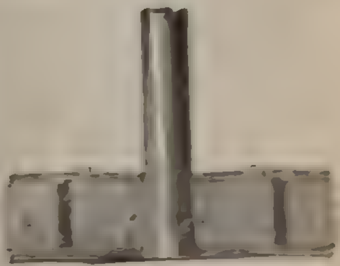


... piston has been considerably modified by various engineers, which we ... to notice hereafter, we shall here state briefly that it consisted of two ...ass, of the full size of the cylinder; these rings were each cut into ...ore segments, and laid one over the other, so as to break the con... the vertical joints between the segments; concentric with these seg... a similar arrangement of segments inside the others, which were ... stop the steam from passing horizontally; in the cavity between all ...nts were placed feather springs, designed to press the segments outward ...the cylinder as either that or the piston wore. These pistons, however, ...y defective; for as the exterior segments wore, and conformed to a ...e, the inner segments, which had no wear, were no longer concentric ... outside of them, and crevices were thus opened, through which the ...ped past the piston.

... those persons who directed their attention to the improvement of ...ant part of the engine, Mr. John Barton was the most successful. ...exed engravings, *Fig.* 1 represents a plan of the piston, with the top

Fig. 1.

Fig. 2.



...oved, and *Fig.* 2 a vertical section of the same, taken on the line ... ...lan. a a a a are four metal segments ... b b b b, four ...

interposed between the segments, their points forming a portion of the periphery; *c c c c* is a thin steel spring, formed into a single broad hoop, and pressed into the undulated form represented, by which it is found to act with uniform energy upon the wedges, until they and the segments become so much worn in the course of time, that the steel spring recovers itself into its original circular figure; *d* is the frame-work cast in one piece with the lower plate of the piston; *e* is the piston rod; the dark spaces shown on the plan within the circular frame *d* are cavities to lessen the weight of metal; the other dark spaces are cavities to allow of the free action of the circular spring.

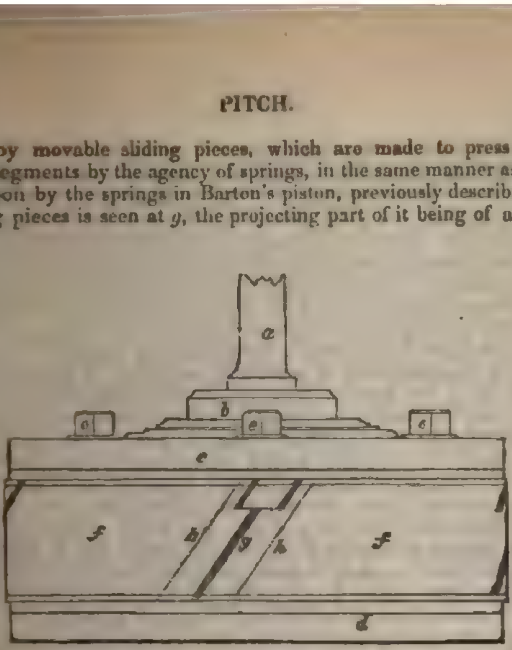
To prevent the segments from falling out of their places whilst the piston is being taken out, or put into the cylinder, the periphery of it is grooved near to its upper and lower edge, in which are sunk two slight spring hoops, cleft across into forked joints, which close together simply by their elasticity. To lubricate the piston, there is a third groove, made midway between the two former for the reception of the oil; these parts are not introduced into the figures. The action is as follows: as the piston and cylinder wear away by the friction, the circular spring *c* presses out the wedges *b*, and these project the segments against the cylinder; and as the segments become reduced, the wedges fill up the increasing opening between them.

An objection has been raised against this piston, that as the wedges must move through a greater space than the segments, in order to press the latter into the circumferential line, the wedges must in consequence rub twice as much against the cylinder, and consequently score it. This objection we believe to be unfounded; and as far as our experience and observation have extended, we have found the wear very uniform. Mr. Barton, perhaps, softens the segments, or makes them of an alloy, which is more easily abraded than the segments; sometimes (we have been informed,) he obviates the supposed tendency of scoring, by cutting out a portion of the end of the wedges, so that they do not bear upon their whole depth or thickness against the cylinder, consequently they will abrade twice as fast as the segments, supposing them to be equally hard. A great variety of metallic pistons have been made of late years, but we know of none that have so fully answered the purpose as the recently patented improvement by Mr. John M'Dowall, of Johnston, near Paisley, who has a manufactory of them at Manchester, where, we understand, great numbers are advantageously working in the engines of the factories. We have seen them in other parts of the kingdom, and can attest their superior excellence.

In the specification of his patent, Mr. M'Dowall states, that his experience in the working of cast-iron pistons led him to observe that the surfaces of the metal betweeen the segments and the plates against which they slide rapidly corrode, and become converted into a substance resembling plumbago, by which the effectiveness of the piston is of course seriously impaired. As a remedy for this defect in cast-iron pistons, he lines or covers the aforesaid surfaces with plates of brass or gun metal, which he connects by screwing or pinning to the cast-iron, and thus acquires the durability of the gun metal at a trifling additional expense above cast-iron.

Another important improvement which Mr. M'Dowall has introduced, consists in a modified construction of the segments, and in the steam [illegible] or slides by which they are pressed outwards. In the figure on the n[illegible] page is exhibited an external elevation of one of these cast-iron pistons: [illegible] the piston rod which passes through a solid central block, the upper par[illegible] which is seen at *b*, and through the top plate *c*, and bottom plate *d*, the la[illegible] being made fast to the bottom of the central block through the medium of [illegible] piston rod; the top plate *c*, for the convenience of removal at pleasure, is [illegible] tened to the central block *b*, by means of screws *e e e*. Between the to[illegible] bottom plates, and around the periphery of the central block, are fitt[illegible] expanding ring of segments, two of which are seen at *f f*; these se[illegible] instead of being divided by perpendicular cuts, as usual, have thes[illegible] inclined, as seen at *g*, which thus overlap each other, and cause the cy[illegible] be equally worn, (which would not be the case were the apertures bet[illegible] divisions vertical.) The inclined crevices through which the steam m[illegible]

ped by movable sliding pieces, which are made to press continually the segments by the agency of springs, in the same manner as the wedges d upon by the springs in Barton's piston, previously described. One of iding pieces is seen at *g*, the projecting part of it being of a rhomboidal



that fills up corresponding notches made in the corners of the seg- and those parts which come in contact, and are represented by a single e faced and ground to each other, to prevent the upward or downward of the steam; and to stop it laterally, the slides are ground to fit the backs segments to which they are connected, by dove-tailed grooves, represented two parallel dotted lines *h h*. The double lines at *i*, both above and below gments, indicate the brass linings before mentioned. Mr. M'Dowall's includes the application of the same improvements, namely, the sliding stops, and the brass linings to the air-pump buckets of steam engines, bed under the article Valve, to which his principal improvement in ppendage relates.

ICH. A resinous substance, obtained by the inspissation of tar. There o methods of obtaining it; one by simply boiling the tar in large iron or by setting it on fire and letting it burn until it obtains such a consistence dipping a stick in it, and exposing it to the air, it readily solidifies. Two of the best tar, or two and a half barrels of green tar, are thus con- into one barrel of good pitch. The foregoing has reference only to tar ed from the pine-tree and other vegetable matters; but a large quantity tar and pitch are obtained in this country from coal. On the banks of the Junction Canal, in the vicinity of the large iron and coal works, there established some years ago several "tar-works," to which the iron masters raw coal, gratis, and received, in return, the cokes produced by such the proprietors of the tar-works being contented with the compensation by the *smoke* alone: the following is the process of obtaining it:—A of eighteen or twenty stoves is erected, and supplied with coal kept at the bottom; the smoke is conducted by proper horizontal tunnels into and close funnel, of one hundred or more yards in length: this funnel of brick, supported by brick arches, and covered on the top by a shallow of water, which pond is supplied with water, when wanted, by a steam engine to the coal or iron works. The coldness of the water gradually con- the smoke, causing the tar to fall on the floor of the funnel, whence it is by pipes into a receiver; from the latter it is pumped into a boiler, rated to the required consistence, or otherwise inspissated into pitch: latter is the case, the volatile particles which arise during the inspis- are again condensed into an oil used as a varnish. In this process the

ke is decomposed, nothing arising from the work but a white vapour from e small funnels (kept open to give draft to the fires), and a small evaporation vater from the pond, occasioned by the heat of the smoke underneath it. process requires but little attendance, the principal labour being that of lying the fuel. In a tar-work, where twenty tons of coal are consumed day, three labourers and a foreman do the whole business; and the quan- of tar produced will be about 28 barrels of $2\frac{1}{4}$ cwt. each; or 21 barrels of h of the same weight, in six days. Some coals are, however, so bituminous o yield one-eighth of their weight of tar.

IVOT. A short shaft on which a body turns or revolves.

LAN. A representation of something according to the proportion of its s, made on a flat surface, as on paper, pasteboard, &c.; such are maps ts, &c. By the term plan, however, a draughtsman understands it to be r a ground plan of a building, machine, &c., or the arrangement and t proportions of a horizontal section made in any part of the same.

LANE, in Geometry and Mechanics, a perfectly flat surface in whatever tion, as horizontal plane, vertical plane, inclined plane. If a sphere be cut plane, the section will be a circle. If a prism or cylinder be cut by a e, either through or parallel to its axis, the section will be a parallelogram, if either of these be cut by a plane parallel to its base, the section will be lar to that base. Also, if a cylinder be cut obliquely by a plane passing ugh its opposite sides, the section will be an oval or ellipse. If a pyramid one be cut by a plane passing through the axis, the section will be a triangle, if they be cut parallel to the base, the section will be similar to the base. cone be cut by a plane parallel to its side, the section will be a parabola; if e cut obliquely, so that the plane does not pass through either the base or opposite cone, the section is an ellipse; if it be cut by a plane which es through the base and the opposite cone, but does not pass through the ex, the section is a hyperbola; and, lastly, if it be cut by a plane, either llel to the base, or in sub-contrary position to it, the section is a circle.

LANE. An instrument employed for shaving wood and other substances true plane or smooth surface, of which there are a great variety: they are lly divided into two principal kinds, namely, bench-planes and mouldings es; of the former, the principal are the long, jack, trying, and smoothing es: each of these is again distinguished into double or single iron, according he cutting part is formed. The single iron is an iron blade, the lower of hich is steel; and the cutting-edge is formed by grinding it to a single angle le, as represented by the piece marked *d* in the following cut; its operation artly of a cutting and partly of a scraping nature. In planing rood great inconvenience was found from this form by its frequent he surface instead of smoothing it; a partial remedy for this equence, introduced about thirty years ago, by which anoth d a "top-iron," represented at *e*, was added to the under by means of a strong connecting screw, which causes the to press closely upon the lower one. The cutting-edge which projects a little beyond *e*, is, therefore, the same efore; but it is prevented from entering so deeply into wood, or rather, the shaving which has been abraded from wood receives a new direction by the abrupt interposition he top iron *e*, and prevents the surface of the wood from g torn. This improvement is so decided as to cause e of single iron planes. The remedy, however, is incom the planing of very hard woods; for which purpose, i amson, of Kennington, has found it advantageous to d, by making it of greater thickness, and giving it a beve bottom sides, at an angle similar to that shown on the un altered form of edge, it will be evident that it partakes n; yet it is found to obviate more effectually the defects The edge is stronger and more durable; it gives ice almost without the aid of the scraper; and, from its

entitles the inventor to the reward (of ten guineas) given to him for it by the Society of Arts. It is peculiarly valuable in planing hard woods across the grain, as in preparing box for the use of engravers.

PLANE-CHART, in Navigation, a sea-chart constructed on the supposition of the earth and sea being an extended plane surface. Such charts have, consequently, the meridians represented as right lines to each other.

PLANE-SAILING. The art of performing the several reckonings necessary in conducting a ship on the ocean on the principles of the plane-chart.

PLANE-TABLE. An instrument by which the draught or plan of an estate, &c. may be taken on the spot, while the survey or measuring is going on. It consists of a perfectly flat rectangular board, sufficiently large for the paper, the centre of which moves freely on a ball and socket attached to the top of three legs, on which the instrument stands; by this means, when the legs are fixed in the ground, the table may be inclined or moved round in any proposed direction. For the purpose of fixing a sheet of paper on the table, there is a frame of wood, which fits exactly round its edges; one side of this frame is graduated into equal parts, and the other side into degrees from the centre of the table; by which means this instrument is made to answer the purpose of a theodolite. To the side of the table is screwed a magnetic needle and compass, to take directions and bearings; and, lastly, there is a brass two foot scale, furnished with two open sights, or else a small telescope, serving as an index. The use of the plane-table is as follows:—Having moistened a sheet of writing or drawing paper, spread it flat on the table, and secure it in this situation by pressing down the frame on its edges. When this paper is dry it will be perfectly smooth, and ready to have drawn on it the plan of the proposed survey. We then begin by setting up the table at any part of the ground that is judged most proper; and having done this, a point is made in some convenient part of the paper to represent the spot where the instrument stands; we are then to fix in that point of the paper, on a leg of the compasses, or a fine steel pin, and apply it to the fiducial edge of the index, moving it round the table close to the pin till some desired point or remarkable object, such as the corner of a field, a tree, a picket, &c. be seen through the sights; from the station point an obscure line is then to be drawn along the fiducial edge of the index. We then turn the index to another object, and draw a line on the paper towards it. The same process is repeated till as many objects are set as may be deemed necessary for the purpose. We then measure from our station to each of these objects, taking the necessary offsets to corners and bendings of the edges, &c., laying down the measured distances, taken from a proper scale, upon the respective lines on the paper. The table is then to be removed to any one of the objects to which the measuring was made, as a second station. Here it must be fixed in its original position, turning it about its centre for that purpose, both till the magnetic needle points to the same degree of the compass as at first, and also by laying the fiducial edge of the index along the line between the two stations, and turning the table till the former station can be seen through the sights on the index: it is to be fixed in that position. From this new station repeat the former operations, setting several objects by the edge of the index, and measuring and laying off the distances. In this manner we proceed from one station to another, measuring such lines only as are indispensable, and determining as many as possible by intersecting lines of direction, drawn from different stations. If, before the survey is completed, the paper be full of lines, measurements, &c., recourse must be had to another sheet of paper. Draw a line in any manner through the farthest point of the last station line to which the work can be conveniently laid down; then remove the sheet from the table, and fix a perfectly clean sheet in its place, drawing upon it, in a part the most convenient for the rest of the work, a line to represent that drawn at the end of the work on the former sheet. Cut or fold the old sheet by this line, and apply the edge so that it may exactly coincide with the corresponding line on the new sheet. While they lie together in this position, produce the last station line of the old sheet upon the new one,

and place upon it the remainder of the measurement of that line, beginn where the work ended on the old. In this manner the process may be continu from one sheet to another, till the proposed survey is complete. When survey is finished, the sheets are all to be fastened together, taking care the lines in one sheet accurately meet the corresponding lines in anot throughout.

PLANETARIUM. An astronomical machine of the same nature as orrery, designed to exhibit the orbits, motions, and phenomena of the plane the solar system. In a machine of this kind, which was constructed by Huyg and is preserved in the University of Leyden, the revolution of the prim planets about the sun, and that of the moon round the earth, are performed the exact time that they are actually performed in nature. The orbits of moon and planets are here represented with their true proportions, eccentrici positions, and declinations from the ecliptic; and by this machine, as by a p petual ephemeris, the situations, conjunctions, oppositions, &c. of the plan for any time may be accurately determined. Dr. Desaguliers constructed very complete planetarium, which he has described in his *Course of Exp mental Philosophy*, published in 1734; but the most stupendous, superb elaborate planetarium ever constructed, was that which was publicly shown London in 1791, and afterwards purchased by government to be sent out w Lord Macartney, in 1793, as a present to the emperor of "the *Celestial* empi It exhibits all the bodies, both primary and secondary, of the solar system, their orbits in their due proportions and positions, and all performing annual and diurnal motions exactly as in nature, exhibiting, at all times, true and real motions, positions, aspects, phenomena, and even the inequalit of their motions in elliptical orbits. As engravings of planetariums have, ho ever, been exhibited in all the Cyclopædias and works of mechanical scien and as every mechanic well understands that their motions are regulated b numerous train of wheels, which it would be extremely tedious to detail, p cisely in the same manner as in horological machines (the hands or indexe which, instead of bearing planets at their extremities point out the time), shall content ourselves with referring the reader to the article ASTRONOMY in *Oxford Encyclopædia*, for a very full and interesting account, illustrated engravings, of several admirable machines of this kind.

PLANING MACHINES. For the planing of wood and metal on the la scale, by power, extensive and varied mechanism has been employed; to invention and furtherance of which the late Mr. Bramah largely contribut Under the article FLOORING we have described Mr. Muir's patent pla machinery.

PLATINA. One of the metals, and the heaviest body hitherto discovered nature; its specific gravity being 21.54 when pure. It is obtained from an or metallic sand brought from South America, which contains, besides platina, f new metals, namely, palladium, iridium, osmium, and rhodium; also iron chrome. Platina, combined with palladium and rhodium, is as hard as i It is not altered by exposure to the air, neither is it acted upon by the m concentrated simple acids, even when boiling or distilled from it. It is v malleable, though considerably harder than gold or silver, and it hardens m under the hammer. Its colour on the touch-stone is not distinguishable f that of silver. Pure platina requires a very strong heat to melt it; but w urged at a white heat, its parts will adhere together by hammering. This p perty, which is distinguished by the name of welding, is peculiar to platina iron, which resemble each other, likewise, in their infusibility. Platina obtained by dissolving the crude metallic particles in nitro-muriatic acid, pr pitated by ammonia, and exposed to a very violent heat, by which the acid alkali are expelled, and the metal is reduced in an agglutinated state, whi may be pressed together by a button-headed iron, be taken out of the furn forged, reheated, and forged again into a bar. Willis found that platina m sometimes be melted upon a bed of charcoal in a crucible; and M. Beaufoy recently found that it might always be melted in a blast furnace, if the cruc

lead made with a mixture of clay and charcoal; the silicon, in his opinion, ...ing in the reduction. Platina may be melted in quantities not exceeding ...ounces at a time, by the oxy-hydrogen blow-pipe, and be kept in fusion for ...w time. Platina is much used for crucibles, evaporating dishes, and even ...mbics. Though it resists most of the acids, it is acted upon by caustic ...ash, and several of the neutral salts. The proper solder for it is gold. ...e concentration of sulphuric acid is now usually performed by platina stills, ...h leaden heads. Mr. Parkes has one of this kind, which holds only thirty- ... gallons, yet cost 300 guineas.

PLATING, or PLATED MANUFACTURE. The art of covering other metals ...h silver. The method known by the name of French plating was usually ...ed to articles made of brass, after they were, in other respects, finished. ...r the goods were polished, and perfectly free from grease, &c., the part to ...plated was heated to a temperature somewhat short of changing the colour ...the metal. Leaf silver was now laid upon the part, and, while hot, was ...ed on with a hardened steel burnisher, perfectly dry and clean. By this ...s the silver adhered firmly to the brass, which, from the action of the bur...her, assumed a fine polish: these had much the appearance, in colour and ...r, of those of the present day; but they possessed but little permanence ... art is, therefore, scarcely now practised, from the introduction of the supe... plan of plating upon ingots of copper, and forming the utensils out of the ...s and the wire made from the ingots.

The plated manufacture is divided into three departments, to each of which ...e is a distinct set of workmen. Those employed in making vessels such as ...required to be raised by the hammer, are called braziers. The second sort ... called candlestick-makers, being exclusively employed in making all the ...ers of these articles. The third are called pierce workers; these were ...rally employed in making articles with ornamental open work, such as ...d-baskets and trays of different kinds; but this species of work has now ...me obsolete, since the invention of plated wire. The articles in which ... work had been made, are now formed by the varied intersections of ...es, which give great lightness and elegance, with less waste, and more expe...on.

Previously to describing the different branches of this art, we shall give the ...thod of preparing the plated sheets and wire, of which all the different ...cles are made. The ingots on which the silver is laid are not pure copper, ... an alloy, consisting of copper and brass; this gives it a degree of stiffness ...er than that of copper, which renders it less liable to be deformed when in ... The metals are melted to a proper heat, in a peculiar furnace appropriated ...that purpose. The heat of the metals, and the temperature of the mould ...o the metal is poured, are of great importance as far as regards the sound... of the ingot. When the metal is too cold, and its liquidity of course ...rfect, the impurities cannot freely ascend, which causes imperfection in ...substance. The same effect may take place from the moulds being cold; ... with the great conducting power of the metal mould, rapidly robs the ...al of its caloric, and lessens its liquidity. The proper heat for the moulds is ...ewhat short of burning the fat with which they are greased on the interior ...ce. For the ordinary kind of work these ingots are generally cut in two ...the middle, being more convenient for plating than longer pieces. The next ...ess is to dress the face of the ingot for the purpose of receiving the silver on ...e both sides, as it may be intended to be single or double plated. This is ...ed by filing, which is continued till the surface becomes entirely free from ... least blemish: this is so important that the naked eye should not be ...ded upon; the surface of the copper should, therefore, be minutely ...mined by a magnifier before the silver is laid on. The thickness of the ...r to be laid on the copper will be best known when it is understood that ... silver, on single plated metal, or that plated on one side only, is from eight ... pennyweights to the pound troy of copper; and, of course, double quan... when plated on both sides. When the plate of silver is cut to a little less ... the size of the copper surface, made flat and scraped perfectly clean, the

copper surface being equally clean, they are laid together, and the silver plate is tied down with wire. A little of a saturated solution of borax is now insinuated under the edge of the silver plate on each side; this fuses at a low red heat, and prevents the oxygen of the atmosphere from affecting the surface of the copper, which would prevent the adherence of the silver. In this stage the ingot is brought to the plating furnace; this furnace has a grate on a level with the bottom of the door. The fuel consists of cokes. The ingot is laid upon the bare cokes, and the door shut. When it has acquired nearly a proper degree of heat, the plater applies to the hole in the door to observe the proper point when the process is finished. When the silver and copper are uniting the surface of the former begins to be rivetted, and this is the sign to remove the ingot from the fire as quick as possible. The ingot being now plated, is made perfectly clean, and is ready to be rolled. The first rollers employed for plated metal are of cast iron, similar in size and construction to those employed for sheet iron and sheet copper. The metal is rolled cold, and annealed from time to time. When it has gone through the rollers a certain number of times it acquires a certain degree of hardness, so that the rollers have not much effect upon it; and if the rolling were continued, the metal would crack. To remedy this evil the metal is taken to a reverberatory furnace: it is laid upon a hearth of brick or fire-stone, and the flame of coal is made to pass over it: the heat, however, is not intense, since the metal is required to be slowly heated to a dull red. It may now be cooled in the quickest way possible, to save time, as quenching in water does not harden it, as is the case with steel. It now passes through the rollers as before, till it becomes hard, and then annealed and rolled again, till it is reduced something short of the size required. This being done, it is again annealed and passed through a pair of rollers faced with cast steel, and finely polished: this gives the surface great smoothness and truth. It is now annealed for the last time: after this the sheets are immersed in hot dilute sulphuric acid, then scoured with fine Calais sand, which fits them for the workmen to shape into different articles.

The first mode we shall describe is that of the braziers, or those who work with hammers. The nature of sheet metal is so similar to copper, that the working of it with the hammer, into various forms, will be very similar to that used by coppersmiths, with the difference of more exact and complete tools, and greater care on account of the value of the metal. Formerly all the different shaped vessels were made with the hammer, which made the price of labour very great. Now, all vessels of simple form, and not of large size, are formed in dies by means of the stamping hammer. This operation is now so general that some manufacturers employ as many as six or eight of these engines. The dies are, or ought to be, made of cast steel; but it should be as hard as to work to iron, so that the iron should not be much below the surface of the die. When the die is placed upon the anvil, and the metal cut into pieces of proper size, the next thing is to surround the top of the die with a paste made with oil and clay, an inch or two above the surface. This cavity is now filled with melted lead. The under side of the stamping hammer has a flat face of iron fitted to it, about the breadth and length of the die; this is called the licker-up. When the lead becomes solid, the hammer is raised to a certain height and let fall upon it. The under side of the licker-up, from being cut on the surface into teeth in shape like those of a rasp, firmly adheres to the lead, which afterwards rises with the hammer; the metal is now placed over the die, and the hammer, with its lead, made to fall upon it till the impression on the metal is complete. If the vessel to be stamped be of any considerable depth, two or three dies are often used, one larger than another, the last being of the proper size and shape. It sometimes happens that when the vessel has a long conical neck, they are obliged to have recourse to an auxiliary operation called drafting. Cylindrical and conical vessels are mostly formed by bending and soldering. The bending is performed on blocks of wood with wooden hammers, to avoid injuring the plated surface.

Vessels intended to have other forms are generally soldered up in a conical or cylindrical form, according as the width at the top and bottom of the vessel

metal is so malleable, even in the soldered part, that a skilful n give almost any form to a vessel with the hammer. Mouldings es formed upon the edges of vessels, which serve to give much d stiffness, as well as being ornamental. In forming substances a massive appearance, such as the feet of tea-urns, the handles of plated table-spoons, no other metal is employed but the sheet. is formed of two shells, which, when put together, form an olid. Each of the concave parts is first filled with soft solder, en fitted accurately together, and heat applied till the mass fuses, apparently massive article consists of a shell of plated metal oft solder. Bulky ornaments in the form of shells and flowers are ut on in this way; some in silver: these have a similar massive to, and strongly imitate, real plate. All goods formed by hand with require great labour in finishing; for, after hammering the vessel per shape, the marks of the hammer appear like so many flat places, e removed from the outside of the vessel to the inside, when the ncealed, as in tea-urns: this is effected by covering either the anvil mer with a piece of the stuff called everlasting. The roughness is to that surface in contact with the everlasting. In hammering l from time to time, it requires to be annealed by heating it red-hot; rs both the silver and the copper. These are cleaned by boiling in uric acid, and scouring with Calais sand. The sulphuric acid to the very small proportion. If the silver begins to appear black by acid is too much, and must be watered. When the vessels are every respect by the maker, and the surface free from oxide, it fre- ppens that bits of rosin used with soft solder adhere to it; this is boiling in a weak solution of pearl ashes: the same is also used the surface of tinned copper.

nd mode of operation we shall describe is the candlestick-making. In of the business there is great variety. In the commencement of the object was chiefly to imitate those made of silver, and it began evailing taste of imitating the different orders of architecture. The points and prominences thus introduced were ill fitted for plated n a very little time their silver disappeared, which gave them the by appearance possible. This obliged the manufacturers to make plain and simple, and it was not till the discovery of the silver edges sticks of plated metal began to gain respect in the world of luxury . The stems of candlesticks have been made square; some with s with rounded corners; others oval, but the greatest number with , which appear to be the most consistent and the most permanent. he patent telescope candlestick has had the greatest run: this con- cylindrical part lengthening and shortening at pleasure, by one tube the other. The feet of candlesticks, or the base, are generally made the stamp. The neck, which is sometimes small in one part, is also The dish part of the nozzle or socket is made in a die, and the tube same way as the cylindrical pillar. These, for the sake of neatness tion, are generally drawn by the wire-drawing machine, whether for not. The prominent moulding and beads are generally of silver. t parts are soldered together, some parts with hard, and others with The branches of candlesticks are formed in two halves, like the , &c.

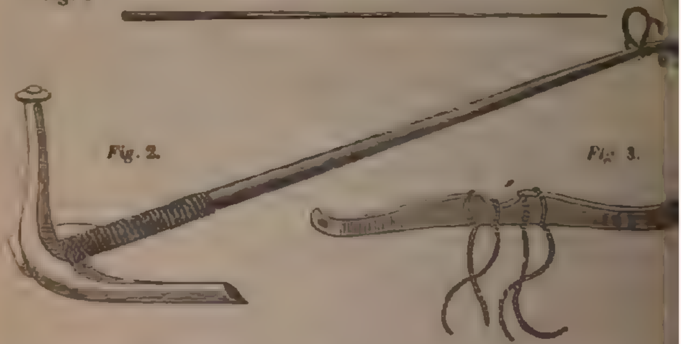
n forming such articles as are made of wire, such as bread-baskets, and castors, the wire is bent into the given form with a wooden mallet. When pieces require to be soldered together, the joinings curately fitted, in order to prevent the copper from appearing. In hard solder is employed. This branch of plated manufacture extensive application, wires being capable of a great variety of

e different plated goods come out of the hands of the workmen, the ugh clean, is of a dull white colour, possessing no polish whatever

This last finish is called burnishing, and is generally performed by females, distinct set of apartments. The burnishing tools are generally made of b stone, and some of hardened steel finely polished; the latter are to burnis minute parts which cannot be touched by the blood-stone, which are empl chiefly for the greater and uninterrupted parts. The bits of blood-stone into little cases, made of sheet iron, and then finely polished. The burnis if used dry, would adhere to the silver in some places, and would scratch in of giving the fine polish: this is obviated by frequently dipping the bur ing tool into a solution of white soap. After being burnished they are r and lastly wiped with clean sheep's leather.

PLOUGH. An instrument employed in agriculture for breaking and tu up the soil in furrows expeditiously. The invention is of very remote antiq The most ancient of ploughs on record are still used in their simple pri form in many parts of the East Indies. In the following figures are exh a correct delineation of one of these miserable machines, of which

Fig. 1. *Fig.* 2. *Fig.* 3.



thousands are at this time engaged in tilling the land that supplies us wi and other products of agriculture. *Fig.* 2 is the plough, made of woo parts being bound together by ropes; *Fig.* 3 is the yoke, designed for a p buffaloes. The husbandman holds the plough by one hand, while, in the he holds the goad, *Fig.* 1, with which, and his voice, he directs and stim the animals. The British manufacturer who may attempt to supply the A husbandman with better instruments, should, in our opinion, to a certain e copy the form represented, however he may improve upon it in the stabi his metallic substitute, and in the addition of convenient appendages, b in mind the well-known fact, that a workman who is used to a very inferi will, from habit, acquire a skill in using it which he could not exercise readily with an intrinsically superior tool, differing materially from his pr one.

There are no instruments in which there are a greater variety of forms ploughs. Every country in England, and almost every district, have favourites, which, in the opinion of the operators, surpass all others in The probability is, that the difference is not very great in the quantity quality of the work executed by them; and that such difference w general, be in proportion to the proximity or remoteness of the district, or city, where the construction of ploughs is conducted on the large scal upon scientific principles. As our limits will not permit us to give even of the varieties that are figured in the books, we shall confine the subject description of two modern improved ploughs (manufactured under a p granted to George Clymer, of London), one designed for light and the ot heavy land; referring our readers who desire extended information o important matter, to the *Ploughwright's Assistant*, by Gray, 1808, to the

Farmer and Ploughman's Guide, by Finlayson, 1820; and to the article AGRICULTURE, in the *Oxford Encyclopædia* and *Supplement*.

A plough for light land is represented in the following cut, which is a perspective view. *a* is the breast; *b* the beam; *c* the coulter; *d* the coulter-point; *e* the share; *f* so much of the land side of the plough as can be seen. The beam rests upon cross pieces at the head of the plough, and is there secured firmly by a transverse screw-bolt *g*. The hind part of the beam is secured by a movable pin passing through it, and through one of the several holes in the land side; this pin being shifted from one hole to the other, and the beam *b* turning upon the bolt *g* as a fulcrum, it is raised or depressed, so as to adjust its

angle of inclination with the horizon at pleasure, causing thereby the plough to cut a deeper or a shallower furrow. The adjustment in a lateral direction is effected by placing several rings upon the bolt, by the shifting of which the direction of the beam, with respect to the land side, is altered, so as to make a wider or narrower furrow; and, by the same means, the plough is adapted to a single or double team of horses.

The plough for heavy land is very similar in its construction to the one just described, except the breast *a*, which is materially different, as shown in the following cut. *b* is the beam; *c* the coulter, which is of the old kind, that

being found the most efficacious in wet soils; it is fixed to an elongated part on the land side; *d* is the share. These ploughs are extremely light, and are put together, or taken to pieces, in a few minutes, being fastened together by a few screw-bolts; they are, therefore, extremely well adapted for exportation, and for use in hot climates. We have been informed by a practical agriculturist, who has several of these ploughs in use, that they turn the land well, and leave a particularly clean and even bottom.

PLUMB-LINE. An instrument used by builders, consisting of a leaden weight, or bob, suspended to the end of a line, used to determine the perpendicularity of their structures to the horizon.

PLUMB-RULE. A simple instrument, for the same purpose as the foregoing; but in this the bob is suspended to the end of a straight board with a line marked down the centre; so that when the edge of the board is placed

against the wall or other object, the plumb-line should exactly coincide with the line marked on the board, to be vertical; and the amount of deviation from the vertical line is precisely ascertained by the angle of divergence between the two lines.

PLUMBAGO. Graphite, or black lead, is an ore obtained from the mines of Keswick and Borradaile, in Cumberland, from Ayr in Scotland and other places. It occurs in beds of various thickness, and constitutes an important article in commerce. The finer kinds are boiled in oil, and afterwards sawn into the required pieces to make pencils. A considerable quantity is used for blacking and polishing the fronts of stoves and numerous other purposes. It has been very common to apply it, in its impure state, to reduce friction in machinery and rubbing surfaces; and, very recently, Mr. Lewis Hebert, of Chelsea, has applied it, in a very refined state, as a substitute for oil, in diminishing the friction of the rubbing parts of clocks. He applied it to a sidereal time-piece, in January, 1816, between which period and 1827 the time-piece was cleaned three times without renovating the plumbago; the friction places being only wiped with a fine muslin rag. In a communication to the Society of Arts, in 1827, eleven years after the plumbago had been applied only once, he states, that the time-piece was going as well as ever. He found a great difficulty in applying it to the jewelled pallats of the escapement, but obviated it by applying it to the friction plane of the teeth of the swing wheel; and he adds, "so ever since the clock has gone without oil."

The process of applying the plumbago is thus:—Take about a quarter of a pound of the purest black lead, the brighter the better; reduce it to a very fine powder in a metal mortar, and, to judge if it is fine enough, take a small pinch of it between your fingers; after rubbing it a few seconds, if it does not feel lumpy or gritty, but smooth and oily, it is good, and beaten enough; have a glassful of filtered water, take some of the powdered plumbago with the clean blade of a knife, spread it on the water, and stir it well; cover the glass, and let it stand for two or three hours; at the top of the water will be a kind of cream, skim it off with a card, and lay it upon a sheet of paper; when dry, put it in a box, to exclude the dust from it; put the sediment aside, repeat the process with some other water and plumbago, until you have acquired a sufficient quantity of fine powder for your purpose; when the whole of the powder is dry, pound it again in the mortar, or bruise it with the bowl of a silver spoon, upon a clean sheet of paper, and repeat the same process two or three times; if the lead is pure, no more sediment will go down; if some does, wash and dry it once or twice more: as soon as no sediment remains, you may be sure that the plumbago dust is pure, and cannot cause any mischief to the pivots and holes; pour some alcohol (the strongest spirits of wine,) into a small glass; having wiped the pivots of the wheels and the holes of the plates very clean, immerse them into the spirits, and immediately into the plumbago powder, they will be covered with it; take a small pencil brush, such as is generally used by miniature painters, dip it into the spirits, and fill the pivot holes with it; introduce some powder into them with your finger, by rubbing the plates over the holes till the powder is even with their surfaces; put in the wheel and make it revolve in the frame for five or six minutes; do the same to every wheel, and also repeat it two or three times; then the holes and pivots will be charged with a thin crust of plumbago, smoother than any polish you can give them; the piece will go twice as long without cleaning as with oil, and truly; if its movement is entirely secluded from dust, there will be no necessity of cleaning it for twelve years, which will be about the time for renovating the plumbago.

PLUMBERY. The art of casting and working lead. See the article Lead in this work; also *Nicholson's Practical Builder*.

PLUNGER. A long solid cylinder, sometimes used in force pumps instead of the ordinary pistons or buckets.

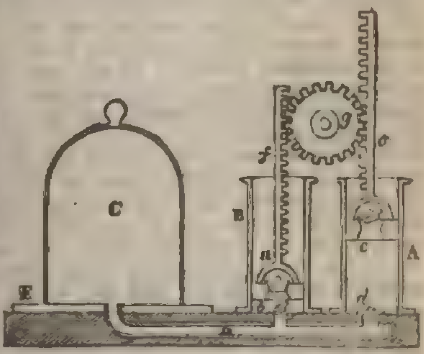
PLUSH. A kind of stuff having a sort of velvet nap or shag on one side, composed regularly of a woof of a single woollen thread and a double warp, the one wool, of two threads twisted, the other goats' or camels' hair. Some plushes in imitation of the foregoing are made of other materials.

PLUVIOMETER. An instrument for measuring the quantity of rain that falls in a given time. See RAIN-GAUGE.

PNEUMATICS treat of the mechanical properties of air, gases, and vapours. All air, gases, and vapours not in contact with the liquids from which they rise, partake of the same general properties; that is, they all possess weight and inertia, impenetrability, compressibility, and elasticity. The impenetrability of air may be made manifest by the impossibility of bringing together the opposite sides of a blown bladder. It may be also shown, by taking a cylinder with a smooth bore, and fitting a piston or plug into it so closely that the air may not pass between its sides and the tube; it will then be found that no power we can command will force the plug to the bottom of the cylinder. In making this experiment, however, we observe two of the most important properties of air, viz. its compressibility and elasticity; for although the plug cannot be forced to the bottom of the cylinder, yet it may be considerably depressed, so that the air is reduced to a much smaller volume, and, consequently, is compressible. On the withdrawal of the pressure another remarkable phenomenon presents itself, that is, the plug is forced upwards to its original position. The especial properties of air are as follows:—

It possesses weight and inertia;
It exerts an equal pressure in every direction;
It is compressible and elastic.

We shall speak of each of these properties in succession; but first it may be necessary to describe the air pump, an instrument which is in the highest degree useful in pneumatic experiments. In the annexed sectional representation, A and B are the barrels of the pump, which must be perfectly cylindrical and smooth within. C is a glass receiver placed upon the pump plate E; and D is a pipe communicating with the receiver and the two barrels: *b* and *d* are valves at the bottom of the barrels, opening upwards; *a* and *c* are valves in the pistons, which must fit into the barrels with the greatest accuracy; *e* and *f* are racks attached to the pistons, and which are moved upwards and downwards by



means of the toothed wheel *g*, which is turned by a winch fixed on its axis. By comparing this instrument with a common water pump, its principle will be found identical; but as air is a much lighter and more elastic fluid, it will require the workmanship in the air pump to be of the most accurate description. In working this pump it will be seen that as the piston in B is raised, the air which previously filled only the receiver and the pipe D will be expanded by its elasticity so as to fill the barrel also; by the next motion of the handle the piston is depressed, and the air within the barrel becoming compressed will close the valve *b*, and open that at *a*, through which it will escape into the atmosphere. When the piston is again raised, the air left in the receiver will be again expanded so as to fill the barrel, and on being depressed, the air will escape as before. We have only in this process noticed one barrel, but the action of both is similar; while one is filling by the expansion of the air in the receiver, the other is emptied into the surrounding atmosphere. By this alternate action of the pistons, the air within becomes considerably rarefied, but as the portion withdrawn is always a definite part of what was previously in the receiver, it is manifest that a perfect vacuum cannot be obtained. We have stated that air has weight: this may easily be shown by means of the air pump. If we take a glass or other vessel holding exactly a quart, and furnished with a

stop-cock that will fit into the hole in the middle of the pump plate, we exhaust or withdraw nearly the whole of the air from the vessel. Now weigh the empty vessel, and afterwards, by turning the stop-cock, let in the difference of weight in the bottle will show the weight of the qua air admitted: this will be about seventeen grains, varying at different both on account of changes of density which take place in the atmosphe the varying quantity of aqueous vapour that it may contain. The air may be seen in the resistance it offers to the motions of bodies imme it. Two sets of small brass vanes are sometimes put into motion by th force under the receiver of an air pump. While the vanes in both are one way, they revolve for the same length of time whether in the air vacuum; but if in one of them the broad surfaces of the vanes are tu the direction of the motion, and in the other the narrow edges, a difference is observed. In an exhausted receiver they continue in during equal times, but in the air, that which cuts the atmosphere edges continues moving for some time after the other is at rest.

Another experiment illustrative of the same fact is termed the guin feather experiment. A long receiver is placed upon the pump plate, guinea and a feather are attached at the top to a little piece of apparatus b they may be disengaged at the same instant. While the receiver is full the guinea reaches the pump plate before the feather, but when the air from the receiver, the guinea and feather fall with exactly the same ve

Since air is fluid, it will manifest the common properties of fluids; example, pressure. If a small vessel, similar to the one here represented, be placed over the hole in the pump plate, and the hand placed closely over the top, when the pump is worked, the hand will be held firmly on the glass by means of the downward pressure. In the same way, the glass receivers are held firmly on the pump plate. If a bladder be made wet, and tightly stretched over the top of the glass, then dried and placed over the hole of the air pump, as soon as the pump is worked, the bladder will appear concave at the top, and will eventually be burst by the great pressure of the superincumbent air. Another apparatus, admirably adapted to evince the great pressure of the air in all directions, is what are termed the Magdeburg hemispheres. It consists of two hemispheres of brass, having their edges accurately ground, so that they may fit together, as in the annexed representation. The part *a* of the lower hemisphere is screwed into the hole of the pump plate, and the air may then be exhausted. If then the handle *b* be screwed on, two persons may endeavour to separate them by pulling in opposite directions, or they may be suspended, and a weight attached to the lower one. It has been ascertained that the actual amount of the air's pressure is about 15 pounds on every square inch of surface; hence may be calculated the force with which the hemispheres are held together, or the absolute pressure upon any surface whatever. Let us suppose that the diameter of the hemispheres is 4 inches, then the area of each of the circles in contact with each other will be 12½ inc multiplying this by 15 lbs. we obtain 187½ lbs. as the pressure by wh hemispheres are held together. In the same way we may ascertain the of pressure upon the human body. Suppose the outer surface of a mid man to be about 14 square feet, then multiplying this by 2160 lbs. th sure on a square foot, we obtain 30,240 lbs. as the pressure upon of an individual of moderate size. If the barometer should fall an inc it frequently does before rain, we are released from a pressure of up 1000 lbs.: this, by diminishing the tension of the different parts of the sufficient to account for that languor which is commonly complained weather. This apparatus was originally designed by Otto Guericke, o

burg, and was constructed on so large a scale that several horses were required to separate the hemispheres.

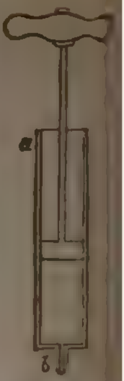
The ordinary or natural state of the air (as we are in the habit of calling it,) is a compressed state; if we attempt to alter it either by further compression, or by taking off the pressure, the elasticity or repulsion of the parts is immediately manifest. The law of compression within certain limits is exceedingly simple, and may be easily verified. Let a long glass tube be closed at one end, as in the accompanying representation. The longer leg may be 30 or 40 inches in length, the shorter 4. Suppose the tube placed in an upright position, and a little mercury poured into it up to the level $a\,b$, then a cylinder of air $b\,i$ will be enclosed and prevented from escaping. If now more mercury be poured into the longer leg till it rise to d in the shorter, the height of mercury in the longer leg above the level $c\,d$ will be found to be about 10 inches, which is $\frac{1}{3}$ of the usual atmospheric pressure. The whole pressure upon the column $d\,i$ being made up of the pressure of the external air, together with that of the 10 inches of mercury, will be $\frac{4}{3}$ of the atmospheric pressure, and the space now occupied by the air is $\frac{3}{4}$ of the original space. If more mercury be added, so that the column may be 30 inches high, the whole pressure will be double the atmospheric pressure, and the space into which the air will be compressed is one-half. If we examine the result of a number of trials made in this way, we shall find them as follows:—

Compressing force	1 .	$\frac{3}{2}$.	$\frac{4}{2}$.	$\frac{5}{2}$.	$\frac{6}{2}$
Spaces occupied. . . .	1 .	$\frac{2}{3}$.	$\frac{2}{4}$.	$\frac{2}{5}$.	$\frac{2}{6}$

If we examine these two rows of fractions, we shall find that the lower are the reciprocals of the upper; whence we see that the spaces occupied by the compressed air are inversely as the compressing forces. But as the density is inversely as the spaces occupied, it is evident that the compressing force is proportional to the density; and further, since the elasticity of the included air is proportional to the compressing force, it is also manifest that the elasticity is as the density, that is, if the density be doubled or tripled, the elasticity will be doubled or tripled, &c.

The elasticity of air by the removal of the pressure gives rise to a variety of entertaining experiments. If a bladder containing a small portion of air be placed under the receiver of an air pump, while the air is exhausting the bladder will be observed to expand till it appears fully blown; on the re-entry of the air the pressure will immediately reduce the included air to its primitive dimensions, and the sides of the bladder will collapse. At the larger end of an egg there is a bubble of air between the shell and the inner skin: if a hole be made at the smaller end, and the egg be placed with the hole downwards in a wine-glass, under the receiver of an air pump, as soon as the air is begun to be withdrawn, the air within the egg will expand and force out the contents into the glass. When the air re-enters, by careful management, the whole may be forced into the shell, so as to have its original appearance. Upon this principle fountains may be contrived. If a glass or other vessel similar to the one here represented, having a tube reaching nearly to the bottom, be half filled with water, and then placed under a tall receiver on the pump plate, the action of the pump commences, the air in the part a not being able to escape, expands itself as the external pressure is removed, and forces the water before it up the pipe, so as to form a continuous stream till the level

of the water reaches the lower end of the tube. If the air in the part *a* could be compressed so that its elasticity might exceed that of ordinary atmospheric air, the fountain would act without being placed under a receiver. For this purpose a condensing or compressing syringe would be necessary to force air into the upper part of the vessel. The compressing syringe differs but little from one of the barrels of the air pump. It has, however, no valve in the piston, but one at the end *b*, opening outwards, and which may be easily formed by tying over the hole a small piece of oiled silk. When this apparatus is to be used, the end *b* is screwed into the mouth of the vessel into which air is to be forced; and the piston being then raised above the hole *a* in the side, the syringe becomes filled with air: the piston is then depressed, and the air is, by its descent, forced into the vessel, and from which it cannot return on account of the valve at *b* opening only downwards. The piston is again raised till above the hole, and another barrel full of air is injected into the receiver. This process may be continued till the air is considered of sufficient density, which may be easily ascertained by knowing the proportio[n] capacity of the syringe and the receiver. If the receiver contain twelve t[imes] as much as the syringe, twelve changes of the syringe will be necessary to d[ouble] the density of the air. It is, perhaps, scarcely necessary to remark that [the] receiver must be strong and furnished with a stop-cock or valve, so that w[hen] the syringe is separated from it the air may not escape. For further info[rma]tion on this science, see Atmosphere, Air, Barometer, &c.



a

b

PONDERABILITY is a quality of bodies that relates to sensible weigh[t] ponderable body is one that possesses sensible weight. A great difference e[xists] in the relative weights of different substances. Thus platinum is 23 times he[avier] than water; water 840 times heavier than air; and air 14 times heavier [than] hydrogen gas. Platinum is, therefore, 170,480 times heavier than hydrogen. It will readily be understood that if any substance exists that is as much li[ghter] than hydrogen as hydrogen is lighter than platinum, the weight of such a [body] would be absolutely inappreciable by any of our present instruments; [such] bodies would, therefore, be called imponderable. In the ordinary divisio[n of] simple substances at present in use by chemists, the whole are classed into [pon]derables and imponderables: the imponderable substances are, heat, light, [and] electricity. Some persons have supposed that the idea of imponderable m[atter] is absurd, and that gravity is a universal property of bodies. However this [may] be, if we consider ponderability as indicating our ability to weigh the b[ody, it] will be manifest that heat, light, and electricity may, with considerable just[ice,] be termed imponderable.

PORCELAIN. A fine kind of semi-transparent earthenware, in imit[ation] of that made in China, and hence called China-ware. The combinatio[n of] silex and argil is the basis of porcelain; and, with the addition of various [pro]portions of other earths, and even of some metallic oxides, forms the diff[erent] varieties of pottery, from the finest porcelain to the coarsest earthen[ware.] Though silicious earth is the ingredient which is present in largest propo[rtion] in these compounds, yet it is the argillaceous which more particularly [gives] them their character, as it communicates ductility to the mixture when [moist,] and renders it capable of being turned into any shape on the lathe, a[nd of] being baked. The clays are native mixtures of these earths; but they are [often] rendered unfit for the manufacture of at least the finer kinds of porcelain, [by] other ingredients which they also contain. The perfection of porcelain [must] depend greatly on the purity of the earths of which it is composed; hence the purest natural clays, or those consisting of silex and argil, [only,] are selected. Two substances have been transmitted to Europe as [the] materials from which the Chinese porcelain is formed, which have [been] named *Kaolin* and *Petunse*. It was found difficult to procure in E[urope] natural clays equally pure, and hence, in part, the difficulty of imit[ating]

in of the East. Such clays, however, have now been discovered in countries; and hence the superiority to which the European porcelain . The fine Dresden porcelain, that of Berlin, the French porcelain, ther kinds which are formed in this country, are manufactured of such , from the use to which it is applied, has received the name of porcelain and which appears in general to be derived from the decomposition of granite. It appears, also, that natural earths containing magnesia with advantage in the manufacture. The proportion of the earths to must, likewise, be of importance; and from differences in this ise, in part, the differences in the porcelain of different countries, as necessity frequently of employing mixtures of natural clays. The municates tenacity and ductility to the paste, so that it may be easily the silex gives hardness and infusibility; and on the proper proportion depends, in a great measure, the perfection of the compound. tion of silex in porcelain, of a good quality, is at least two-thirds of ition; and of argil, from a fifth to a third. Magnesia is of use by the tendency which the composition of silex and argil alone has to baking, which is inconvenient in the manufacture. See POTTERY.

ITY is a term in physics, opposed to density, and signifies the relation of matter and space included within the exterior superficies of a volume of a body is the quantity of space included within its external he mass of a body is the collection of atoms or material particles of which Two atoms or particles are said to be in contact when their nearer resisted by their mutual impenetrability. If the component particles ntact, the volume and mass would be identical; but there is good to prove that the particles of no known substance are in contact. llows that the volume of a body consists partly of material particles, of interstitial spaces, which are either empty or filled with some ent substance: these interstitial spaces are called pores. In bodies onstituted, the component particles and pores are uniformly distributed gh the volume; that is, a given space in one part of the volume the same quantity of matter, and the same quantity of pores as an in another part. The proportion of the quantity of matter to the of a body is called its density: if, of two substances, one contains pace twice as much matter as the other, it is said to be "twice as he density of bodies is, therefore, proportionate to the closeness or f their particles; and, consequently, the greater the density the less porosity. The pores of a body are frequently filled with another more subtile nature. If the pores of a body on the surface of the posed to the atmosphere, be greater than the atoms of air, then the ade the pores: this is found to be the case in many sorts of wood open grain. If a piece of such wood, or of chalk, or sugar, be the bottom of a vessel of water, the air which fills the pores will be escape in bubbles, and to rise to the surface. If a tall vessel or a wooden bottom, be filled with quicksilver, the liquid metal will its own weight through the pores of the wood, and will be seen a silver shower from the bottom.

ss of filtration, in the arts, depends on the presence of pores of tude as to allow a passage to the liquid, but to refuse it to those om which it is to be disengaged. Various substances are used as whatever be used, this circumstance should always be remembered, tance can be separated from a liquid by filtration, except that whose larger than the pores of the filtering substance. In general, filters separate solid impurities from a liquid. The most ordinary filters , paper, and charcoal. When the liquid is of a corrosive nature, the stronger acids, pounded glass is frequently employed.

ized substances in the animal and vegetable kingdoms are, from ature, porous in a high degree. Minerals have various degrees of Among the silicious stones is one called hydrophane, which manifests in a very remarkable manner. The stone in its ordinary state is

semitransparent; if, however, it be plunged into water, when it is withdrawn it is transparent as glass: the pores, in this case, previously filled with air, are pervaded by the water, between which and the stone there subsists a physical relation, by which the one renders the other transparent. Oil or water placed on paper has a somewhat similar effect. A good method of observing the extreme porosity of woods, is to place a piece at the bottom of a vessel of water placed under the receiver of an air pump; during the exhausting of the receiver the air will be seen to issue from a thousand pores on the surface of the wood, and this emission will continue for hours. As the water enters the spaces previously occupied by the air, the body becomes heavier; and even charcoal treated in this way becomes heavier than water. Large masses of minerals, by their porosity, produce most important results: thus the rains which fall, and the snows that melt on the mountains, pass through the pores of the various substances they meet with, and issue forth to refresh the plains in springs which are the origin of the various magnificent rivers that at once fertilise and adorn our globe.

POTASH, or POTASSA, is the protoxide of potassium. It is called the vegetable alkali, because it is obtained in an impure state by the incineration of vegetables. Potash is always formed when potassium is put into water, or when it is exposed at common temperatures to dry air or oxygen gas. By the former method the protoxide is obtained in combination with water; and in the latter it is anhydrous. It consists of 39.15 parts, or 1 equivalent of potassium, and 8 parts, or 1 equivalent of oxygen. Hydrate of potash is solid at common temperatures; it fuses at a heat rather below redness, and assumes a somewhat crystalline texture in cooling. It is highly deliquescent, and requires about half its weight of water for solution. It is also soluble in alcohol. It destroys all animal textures, and, on this account, is employed in surgery as a caustic. It changes the blue colour of violets and cabbage to green; reddened litmus to purple; and yellow turmeric to a reddish brown. It has been called *lapis causticus*, but is now termed *potassa* and *fused* potassa. It is prepared by evaporating the aqueous solution of potash, in a silver or clean iron capsule, to the consistence of oil, and then pouring it into moulds. It may be purified by solution in alcohol and evaporation to the same extent as before, in a silver vessel. The operation should be performed as expeditiously as possible, to prevent the absorption of carbonic acid. A perfectly pure solution of potash will remain transparent on the addition of lime water; will not effervesce with dilute sulphuric acid, nor give any precipitate on blowing air from the lungs through it by means of a tube.

Pure potash, for experimental purposes, may most easily be obtained by igniting cream of tartar in a crucible, dissolving the residue in water, filtering, boiling with a quantity of quicklime, and, after subsidence, decanting the clear liquid and evaporating in a loosely covered silver capsule till it flows like oil, and then pouring it out on a clean iron plate. A solid white cake of pure hydrate of potash is thus obtained without the agency of alcohol; it must be immediately broken into fragments and kept in a well-stoppered phial. Potash is employed as a reagent in detecting the presence of bodies, and in separating them from each other. The solid hydrate, owing to its strong affinity for water, is used for depriving gases of hygrometric moisture, and is admirably fitted for forming frigorific mixtures. Potash may be distinguished from soda by a test recommended by M. Harkort. Oxide of nickel when fused by the blow-pipe flame with borax, gives a brown glass; and this glass, if melted with a mineral containing potash, becomes blue,—an effect which is not produced by the presence of soda.

POTASSIUM. A metallic substance, the base of potash: it was discovered by Sir H. Davy, in 1807. It was prepared by causing hydrate of potash, slightly moistened for the purpose of increasing its conducting power, to communicate with the opposite poles of a galvanic battery of 200 double plates; when the oxygen, both of the water and the potash, passed over to the positive pole, while the hydrogen and the potassium appeared at the negative. In this way only small quantities can be procured; but it may be formed more abundantly by the method of Gay Lussac and Thenard. This consists in

fused hydrate of potash in contact with turnings of iron heated to in a gun-barrel. The iron deprives the water and potash of oxygen; gas, combined with a little potassium, is evolved, and pure potassium and may be collected in a cool part of the apparatus. Potassium may prepared by mixing dry carbonate of potash with half its weight of charcoal, and exposing the mixture in an iron bottle to a strong heat: thods have been improved by M. Brunner, who decomposes potash by iron and charcoal. From eight ounces of fused carbonate of potash, of iron filings, and two ounces of charcoal, mixed intimately, and an iron bottle, he obtained 140 grains of potassium. If required to pure, it must be re-distilled in a green glass retort. Potassium is solid inary temperature of the atmosphere; at 70° it is somewhat fluid, its fluidity is imperfect till heated to 150°; at 50° it is soft and and yields like wax to the pressure of the fingers, but it becomes en cooled to 32°; it sublimes at a low red heat, without undergoing e, provided atmospheric air be completely excluded. Its texture is s, as may be seen by breaking it when cold. In colour and lustre it y similar to mercury. At 60° its specific gravity is 0.865, so that derably lighter than water. It is completely opaque, and is a good of heat and electricity. As this metal oxidizes rapidly in the air, or ontaining oxygen, it must be preserved either in glass tubes, her- sealed, or under the surface of liquids, like naphtha, which contain n. If heated in the open air it takes fire, and burns with a purple decomposes water instantly, and so much heat is disengaged that the is inflamed, and burns vividly while swimming on the surface: the unites with a little potassium at the moment of separation, and this takes fire, and augments the brilliancy of the combustion. Under violent action ensues, without the emission of light, and pure hydrogen ; it is also inflamed when placed upon ice, burning a little hole, which filled with solution of potash. Besides uniting with oxygen, to form xide and peroxide of potassium, it combines with chlorine, iodine, sulphur, and phosphorus. When potassium is placed in an atmo- chlorine, it spontaneously takes fire, and burns with greater brilliancy xygen; the result is the chloride of potassium, which is also produced rate of potash is decomposed by heat. Iodide of potassium is formed ssion of light when potassium is heated in contact with iodine. and potassium unite in two proportions, forming, in one case, a solid, other a gaseous compound. The solid hydruret was made by heating in hydrogen gas: it is a grey solid substance, easily decomposed by contact with water. The gaseous compound is formed when hydrate is decomposed by iron, at a white heat, and it appears also to be when potassium burns on the surface of water. Sulphur unites readily of heat, and the compound sulphuret of potassium becomes incan- the moment of union. In like manner, phosphorus combines with forming phosphuret of potassium.

ATOES. A bulbous esculent root, and forming the basis of several res. Under the article BREAD will be found the description of a and process for separating the pure farina or starch from the others it is naturally combined. Under the heads ALCOHOL and DISTIL- also given the processes employed for the conversion of the potato spirit.

CE. Gum sandarach, pounded and sifted very fine, mixed or not with wder of the cuttle-fish bone, and used for rubbing on paper, to prevent thereon from sinking or blotting.

R, in *Mechanics*, is the force which, being applied to any body, *tends* motion, whether it actually produces it or not. In the former case the moving power; in the latter, the sustaining power (See HORSE The term *power* is likewise, for the want of a better word, applied to mechanical *agents* (as we prefer to call them), namely, lever, pulley,

inclined plane, wheel and axle, wedge and screw,—which see: also the artic MECHANICS.

POTTERY. The art of making vessels from earth. In the earliest ag upon record pottery was manufactured. The chief establishments in Englan are in Staffordshire, in a district called The Potteries, at Worcester, Derb Coal-port, and Liverpool. The potteries in Staffordshire employ many thousan of persons, and the value of their produce was estimated at 800,000*l.* per annum The essential material of all pottery is clay, which of itself possesses the tw requisite qualities of being in its natural state so plastic, that, with water, i becomes a soft, uniformly-extensible mass, capable of assuming and retainin any form, and, when thoroughly dried, and having undergone a red heat for time, of losing this plasticity, and of becoming hard, close in texture, and abl more or less, perfectly to confine all liquids contained within its hollow. Th most important circumstances requisite to be considered in selecting the mate rials for pottery are plasticity, contractibility, solidity and compactness afte drying, colour, and infusibility. Wedgewood was the great improver of thi manufacture. The processes employed at most of the manufactories are ver similar, which may be classed under the following heads:—Preparation of raw material, moulding and turning, firing, printing, glazing, and painting. We shall describe these consecutively, as they are conducted at Spode's esta blishment.

In the *preparation of the raw material*, a powerful steam-engine perform many of the processes formerly carried on by manual labour. The bodies o earthenware are composed of Kent flint and West-of-England clay. The flin is first calcined in kilns, similar to those in which lime is burnt; it is the broken by revolving hammers, put in motion by the steam-engine, and afte wards conveyed into the pans, paved with stone, to be ground with water. In the centre of the pans there is an upright shaft, from which several transver arms branch out, having very heavy stones placed between them: these stone moved horizontally by the steam-engines, grind the flints, until they form cream-like liquid, which is let off into the wash-tub, where the coarser partic are separated from the fine; the latter runs off into reservoirs, and the form is carried back to the grinding-pan. When the ground flint is wanted for u it is conveyed from the reservoir by a pump, worked also by the steam-engin The process of preparing the clay, and mixing it with the flint, is thus:—Th clay is drawn up into the upper chamber of the slip-house, and there throw into an iron box, in which moves a shaft, with knives fixed in it, to cut th lumps into small pieces. The clay is now laid in a cistern with a proper qua tity of water, where it softens, and is then put into the plunging-tub; in th tub the water and clay are stirred until they become thoroughly mixed. Th liquid is now drawn off into another cistern, from which it passes through silk sieve into a third cistern; then into a fourth, through silk sieves still fine the ground flint and other ingredients are now brought and mixed togeth and the whole passes through sieves of a greater degree of fineness into fifth cistern: in this is a pump, that throws it into a trough for conveying into the drying kiln. All these various operations are worked by the stea engine, and there are fourteen sieves in motion at one time. After the clay h been dried it is taken from the kiln and laid together in large heaps, and, befo it is worked into the vessels for which it is destined, the air bubbles are dis gaged from it: this is done by a machine turned by the steam-engine. Th machine is an iron box, shaped like an inverted cone, with an upright shaft its centre, to which are affixed knives to cut the clay which is put into the b by their rotatory motion, and, at the same time, so arranged as to force it dow wards to a square aperture at the bottom; it escapes through this in a su ciently compressed state for the workmen, and is then cut into square pieces a convenient size, to be distributed in the manufactory. Near the steam-eng are workshops for those branches of the trade which require the aid of machine and in this building there are eight throwing-wheels and twenty-five turnin lathes. Underneath these shops are drying-houses, heated by steam, in wh

ried, previously to its going to the oven to be fired; above the work-
gle room, capable of holding 200 workmen.

and Turning.—Tea-cups, saucers, basins, jugs, and such like
ive their first shape from the hands of the thrower, who sits on a
flat circular wooden wheel before him, moving horizontally on a
wheel is set in motion by the steam-engine, and the workman can
diminish its velocity as there is occasion. Upon the centre of the
perator throws a lump of clay of the required size, and forms it
ny shape, with the utmost facility; it is then cut from the wheel
nd taken to be dried, that it may acquire sufficient hardness to fit it
operation. By turning, the superfluous parts of the clay are taken
render the article perfectly smooth, and to give it the exact shape.
which the vessels are turned are also put in motion by the steam-
regulated as to speed by the turner himself. The principle of
henware is very similar to that employed in wood turning. The
ring handles and spouts are taken to the handling room, and those
want this appendage, after having attained the requisite hardness,
he oven to be baked. The handles, made on a mould of plaster of
ed to the vessel with a liquid mixture of the same material as the

rmation of various articles manufactured in all potteries, moulds
ter of Paris are necessary. The modeller forms the shape of the
el out of a solid lump of clay, which, after receiving his finishing
nded to the person who makes the plaster mould from it. Plates
re made from moulds of this kind, upon which the operator lays a
of the length, breadth, and thickness required; the mould and
placed upon a wheel turning horizontally on a pivot; and the
ps peeling round with the left hand, and presses the clay to the
mould with the other. The mould and dish together are then
stove moderately heated, where it remains until sufficiently dried
The plate or dish is then cut even at the edges, and in other
hed: before they are baked the dishes are laid flat upon plaster or
at are quite level, in order that they may remain straight until
e oven to be fired. Tureens, vegetable dishes, and such articles,
in moulds, but require more time and care, being less simple in
Figures, flowers, and foliage in bas-relief are also formed sepa-
lds, and afterwards affixed to the vessel with diluted clay.

When the ware is ready for firing, it is placed in clay cases, called
h vary in size and shape according to the articles placed in them.
are put into an oven, shaped like a bee-hive, with an opening at
re is also an opening at the side to admit the saggars, but this is
the fire is applied. Each saggar is luted to the other by a roll of
this secures the vessels contained in them from dust, the fumes
and from the effects of the air when the oven is cooling. The
eat the oven are placed round it in proper receptacles, which
with the interior of the oven by flues, heating every part equally.
g gives a higher degree of heat, and is continued much longer
essive firing; when once fired, the article is called biscuit ware.
loured, or queen's ware is now carried to the dipping-house, to
zing; that which is to be printed blue is taken to the printing-house.
The design is previously engraven on a copper plate, and laid on
rm. The colour (which has oxide of cobalt for its basis) is mixed
ation of oils, to fetch out the impression; this mixture is smeared
ce of the plate and again cleaned off, leaving the liquid in the
ty. The paper used to take off the impression is made expressly
se; it is damped, laid on the copper plate, and passed between two
in ordinary copper-plate printing. The design, being transferred
is laid immediately upon the ware, being rubbed on with a flannel.
g a short time, the ware is put into a tub of water, and the paper
om it by a sponge, leaving the design in the most perfect state.

The ware is then dried, and taken to the oven to be burned; during this operation, the oil which has been mixed with the colour in the printing is destroyed, and the oxide of cobalt more firmly attached to the ware; it is then glazed.

Glazing.—The glaziers differ in their composition in all manufactories; most, however, have oxide of lead for their basis. The ingredients being mixed with water, and well ground, the glaze is ready for use, in which the vessels are dipped. On drying, which takes place instantly, the water contained in the glaze being absorbed by the porosity of the vessel, it is covered with a fine white powder, of a regular thickness; this, when fired, becomes vitreous, or assumes a glass-like appearance, and, from its transparency, the blue pattern underneath is rendered perfectly visible. In the last firing, especial care is taken to keep one piece from touching the other, or the whole would fuse into one united mass. Great attention is also requisite in the firing, not to give too much or too little heat, either extreme being injurious: the fireman in this, as in the other firing, draws out trial pieces from the oven, with an iron rod, to ascertain the proper degree of heat.

Painting.—The pieces of porcelain or earthenware to be enamelled and enriched by gilding, are, after the first firing, dipped in a suitable glaze, and again submitted to the fire; they are then delivered to the painter or enameller. The colours used in enamel-painting are composed of metallic calces and fluxes, suitable to each other, separately and conjointly, and of such a nature as to fuse them sufficiently for the glazing on which they are laid. Gold has also its flux, and is laid on as other colours are. When the painting is completed, the ware is placed in a furnace less in size, and different in construction, from that before noticed. Care is here necessary in the arrangement of the vessels, and great nicety is required in the degree and the continuation of the heat, which is not so intense as in the former firings. The colours after this firing put on a shining appearance, but the gold has an opaque yellow cast, and is burnished with a blood-stone to give it the desired brilliancy.

The deleterious effects of glazes, composed principally of lead, having engaged the attention of the Society of Arts, they were induced to offer their largest honorary premium for the discovery of a glaze for the common red pottery, composed of materials not any ways prejudicial to the health, and which, from its cheapness and fusibility, at the comparatively low temperature required by red pottery, might supersede the use of lead in that branch of manufacture. The following method was communicated to the Society by Mr. Meigh, of Shelton, for which the Society awarded him the premium:—The vessels are to be first dipped in a mixture of red marl, ground in water to an impalpable paste, in order to fill up the pores with the fine particles of the marl; the vessels are then glazed with a mixture of the consistence of cream, of equal parts of black manganese, glass, and Cornish stone, well ground and mixed together, and when the ware is well dried it is fired as usual. For a white glaze, the manganese is omitted.

Owing to the vast extent of the manufacture of refined sugar in this country, there is a very great and constant demand for sugar-loaf moulds, which are a species of unglazed red pottery, made upon the potter's wheel. Messrs. T. and R. Powell, of Bristol, however, by an improved patent process, now form them upon a mould, preparatory to turning, and afterwards give them a glaze both inside and out. The machinery employed by the patentees is represented in the following *Figs.* 1, 2, and 3. *a*, *Fig.* 1, represents the mould formed of wood or plaster of Paris, or both, and turned perfectly smooth; it has a cylindrical pin *b* in the apex, and in the centre of the base, a hole to receive the head of an upright spindle *c*, which projects about an inch through the disc *d*, upon this disc the mould is placed, a small pin from *d* entering a hole in the base to carry it with the disc, when the spindle (which is placed at the potter's table) is set in motion by a band passing round the pulley *e*.

Fig. 2 represents the press in which the clay is prepared for the mould. *a* is the cheek of the press; *b*, a stout triangular box secured to the sides of the press, of the shape shown by the dotted lines on *Fig.* 3; *c*, a table supported by hinges at one end, and at the other by wedges resting on the frame *e*; *d* the

hown separate in *Fig.* 3,) is placed upon the table under *b*; in the thick plank, of the shape of an interior of *f*, and across *b* is placed ck of wood *g*, which is retained in its place by iron straps *h* bolted to ing forelocks passing through the top of them; in *g* works the screw r end being steadied by the cross-piece *l*, and the lower end pressing thick plank in *b*.

presents the plank *f*, which is half an inch thick, and having a piece of the centre (as shown in the figure); the dotted lines represent the ape of *b*, the interior being the same as *f*. The operation is as fol- plank *f* being placed on the table and slided under *b*, the table is

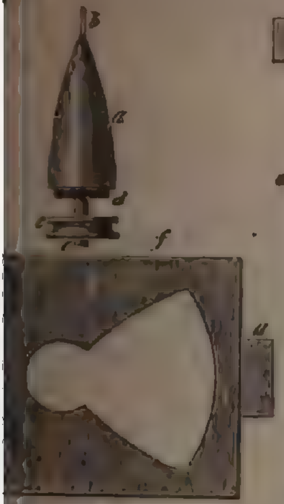


Fig. 3.

Fig. 2.

, and the forelocks are withdrawn from the straps *h*; the block *g* and e raised by a rope; the box *b* is then to be filled with clay, and ith the thick plank before mentioned; *g* is then replaced, and the driven in: the screw being now turned, presses the clay into the mould wire is then drawn through between the plank *f* and the box *b*; the ing knocked out, the plank *f* is withdrawn, and replaced by another, ble again wedged up. The piece of clay in *f* is then to be removed, upon the mould *Fig.* 1, round which it is wrapped, the edges closed nd then turned fair and smooth: it is afterwards removed, when suffi- , to the kiln; and when burnt enough, the salt glaze is given in the ner. Instead of the box *b*, a number of planks like *f* may be placed other, and being firmly clamped together, the clay may be pressed by the screw, and then being unclamped, a wire may be passed be- , which thus gives the clay ready for the turning mould.

PITATE. When a body, dissolved in a fluid, is either in the whole made to separate and fall down in the concrete state, the act of rmed precipitation, and the matter fallen is called a precipitate.

. A machine for the compression of any articles or substances, by tion of screws, levers, wedges, &c. in a convenient manner. As the

combinations of the mechanical powers are almost illimitable, it follows that there may be presses made of an almost infinite variety of forms; but by no possible combination or arrangement of the mechanic powers, can any power be obtained that must be derived from manual labour or some other moving force; and as no motion can take place in any machine without a loss from friction of some portion of the original force applied, that press which imparts the greatest mechanical energy, with the least proportion of friction, and in the most convenient manner, is the best. It however happens in most cases, that friction is reduced in proportion to the excellence of workmanship or perfection of form; and as this circumstance enhances the cost, a preference is often given to machines of rude construction, and of less convenience in form. Under the article OIL we have described a variety of presses of very simple construction, but of great energy and little cost; they are, however, for the most part, not sufficiently compact and convenient for the operations of the packer, or for the general purposes of our manufactories. Screw presses generally consist of six members or pieces; viz. two flat smooth tables of wood or metal; the lower one fixed, and the other above it movable. Between the surfaces of these tables the goods to be pressed are laid, and one or more screws, worked by a lever, are made to force the movable table or board towards the immovable one, and thus produce the pressure on the interposed body. This is the general nature of the machine, of which there are many varieties, each adapted to its own particular purpose. The most modern screw-presses have generally but one screw, preferably made of iron, which, at its lower end, has a massive globular head, with four holes through it, for the reception of the end of the lever employed to turn the screw; the thread of the screw passes through a nut fixed fast in the head or top of the frame of the press. The frame, in this case, consists of a lower bed or horizontal piece, on which the matters to be pressed are laid, two upright cheeks being firmly united with it, and supporting the head or upper horizontal pieces of the press, in which the nut of the screw is fixed; the lower point of the screw is united with the follower, or moving bed of the press, and this rests upon the substance to be pressed, and the power of the screw forces it down upon it. A press of this kind is described under the article HOT-PRESSING, but adapted to the latter object.

Another kind of screw-press consists of two screws, which are immovably fixed in the lower board or bed; and passing through holes in the upper board, have nuts upon them, which, being turned by a lever, draw the two boards together, and exert a pressure upon any thing placed between them. Sometimes the screws pass through the upper board, and are tapped into the lower one; then the screws themselves are turned round by a lever put through their heads instead of turning the nuts. Presses of this kind, when accurately made, have a communication with wheel-work, from one screw to the other, so that both shall turn round together, and cause the two boards of the press to advance parallel to each other. The bookbinder's cutting press is a modification of this, and is used by bookbinders, stationers, and others. See BOOKBINDING.

The screws for presses were formerly made of wood, with sharp threads; that is, the worm of the screw, if cut across, would make a triangular section, the base thereof abutting upon the cylinder of the screw. In this method it was necessary to have the threads very coarse, to give them sufficient strength, and then the power of the screw was not so great as in the other presses, where the screws are made of iron, and their threads not above one-third or one-fourth the distance asunder; the tenacity, hardness, and smoothness of the metal also diminishes the friction considerably. The frames of the modern presses are also made of iron, wood being found incapable of permanently resisting the great strain to which they are subject, as all the fibres, even of the hardest oak, become separated into ribands, and then break, one at a time, till the whole beam fails.

An excellent modification of the screw-press was invented and patented by Mr. Daniel Dunn, of Pentonville, which is adapted to a variety of uses; the following is a description:—Instead of the simple lever, consisting of a long straight bar, which requires so large a space to move it in, the patentee uses a compound lever (much like those employed in the ordinary printing press).

means the same power is obtained in a much more compact apparatus. 1 represents an elevation of the complete press, and *Fig.* 2 a plan of the oved part of the machine; the like letters in each figure denoting similar . *a* is the bed of the press *b b* of massive oak; *b b* the checks or side framing; head; *d* the nut fixed into the head, through which the screw *e* is turned; the platten; *g* the goods, together with the press-boards or metal plates een them. Thus far the press is like others; but instead of having a large -head, with apertures, for the insertion of a long lever bar, that part of crew is squared, and on it is fixed a circular metallic plate or wheel *h*, with ble row of ratchet-teeth; one of the rows of teeth project horizontally the periphery, the other vertically, as will be understood upon examining figures. *i* is the handle of the compound lever, which, being formed into ular eye at the farthest extremity, is thereby fixed upon, and traverses up

Fig. 2.

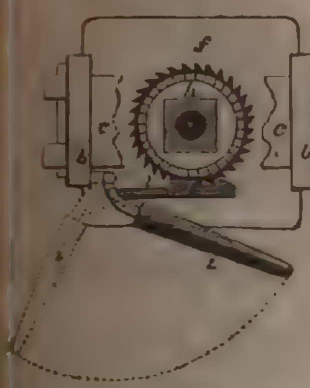
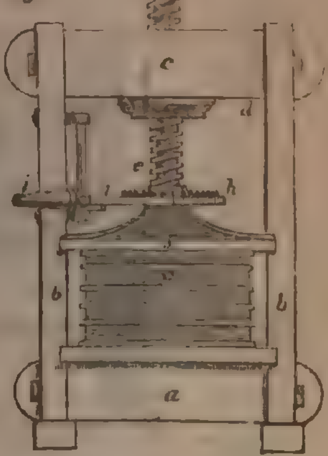


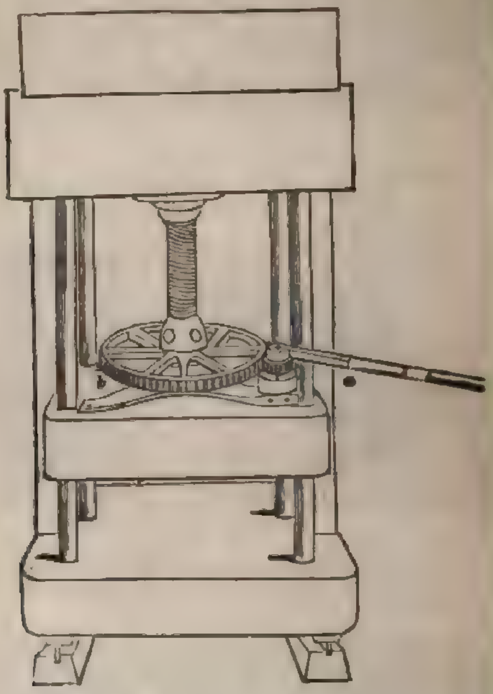
Fig. 1.



own the fulcrum *k*, which is an upright bar firmly bolted to one of the of the press. To alter the power according to circumstances, the d end of the handle *i* is perforated with several holes, to receive a key or which fastens the other portion *l* of the compound lever to it (best seen in); the extremity of *l* is hooked or notched so as to take hold of the teeth e ratchet-wheel, and it has a plate screwed on to it at *o* to prevent it from off. To support the compound lever at the required elevation, a stout passed into a hole, of which there are a series made for the purpose in the heek. In operating with this press, the goods are laid upon the bottom in the usual manner; the platten *f* is then brought down by turning the t-wheel round by hand. The pressure is then given by pulling back the *i* in the direction, and to the position, shown by dotted lines in *Fig.* 2; eatedly moving the handle in this way, the ratchet-wheel is drawn round lever, which causes the screw to descend and to force the platten against ds: during this operation it will occasionally be necessary to let the lever d upon the fulcrum, by taking out the supporting pin, and putting it into xt hole beneath. When it is required to unscrew the press, the hooked the lever *l* is placed in contact with the circle of teeth on the upper sur- f the ratchet-wheel; the lever being then pulled the reverse way, the is raised, and the pressure taken off.

very substantial and practical standing press has been made by Mr. J. L. , type-founder, of Holborn: it is particularly designed for the use of binders, stationers, and printers; the arrangement dispensing with the long

inconvenient lever, as in Mr. Dunn's. It is represented in the followi spective outline. There is little in its structure that varies essential other presses of the kind; the head, bed, cheeks, screw, and nut, regarded as the same. The chief novelty consists in employing, in add these parts, a toothed wheel *b*, fixed on the axis of the screw, and op upon it by the small pinion *c* turned by the lever *d*, which fits on th end of the axis of *c*, whereon it is shifted at every fresh pull. The p



the press, when brought down to the work, may thus be increased in pr to the difference of the diameters between the large wheel and the littl the slow operation of the press at this time is of little consequence. T stands in but little room, considering its mechanical efficacy, and it i factured at a low price.

The foregoing are sufficient examples of the construction of *screw* p we shall therefore proceed to give a description of a most ingenious, ch effective press, in which all the other mechanical powers are brou operation; viz. the *wheel* and *axle*, *lever*, *wedge*, *inclined plane*, and *pu* is one of the inventions of Mr. Ewings, a talented member of the Mechanics' Institution, who obtained for it Dr. Fellowes's annual pri pounds. This press, which is applicable to the packing of goods, pr juice from fruits, oil from seeds, or other purposes to which the screw usually applied, consists of a frame-work, and two or more blocks o between which the articles to be subjected to pressure are to be plac these vary in form, size, and material, according to the purposes for wh are intended. Mr. Ewings does not claim any novelty in the constru these parts, but only in his method of producing the pressure, which is by bringing together the pieces that act on the articles to be pr

wedges: these are forced in by levers (in the manner represented by the following figures 1 and 2), in both of which the same letters of reference represent similar parts. *a* is the base of the press, furnished at each end with ratchet notches *b b*, which constitute the fulcrums of the levers *h h*; *c* is the top of the press, supported by the frames *d d*; and *e e* are the pieces acting on the goods, either downwards, upwards, or both, according as the pressure may be required: in *Fig.* 1 it is represented acting upwards; and in *Fig.* 2 it is represented acting both ways: *f f f f* are friction rollers, between which the wedges *g g* are projected. A cord is fixed to a hook on the end of one of the levers, and passing over a pulley *k*, on the end of the other, is attached to a small drum *l*, which is furnished with a ratchet-wheel and pall, and is turned by a

Fig. 1.

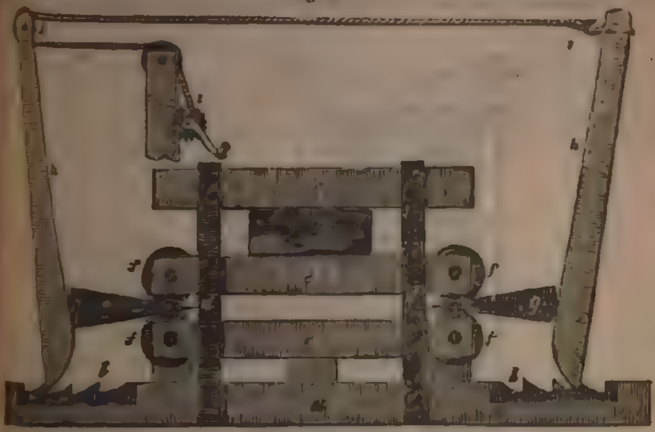
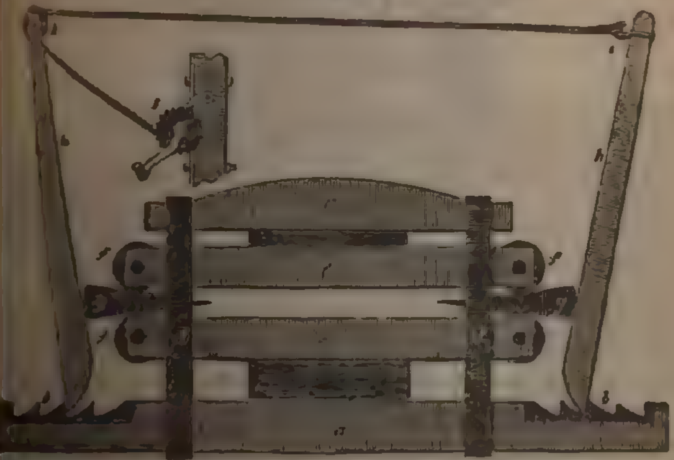


Fig. 2.

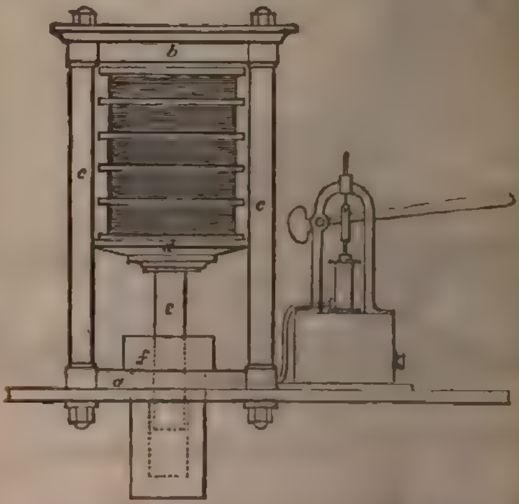


We have seen other modifications of Mr. Ewings's press, but we have selected the above as best calculated to show the principle of its action. Amongst the advantages of this press have been noticed the simplicity and economy of its construction, as it may be made by almost any person accustomed to handle carpenters' or smiths' tools, of very cheap materials; and also

the facility with which its power may be varied: it may be diminish[ed or] increased to any extent, simply by changing the form of the wedges; b[ut the] drawings exhibit its various applications and mode of operation so obvio[usly as] to preclude the necessity of further remarks.

We shall now proceed to the consideration of those presses where[in the] power applied is communicated through the medium of an incompre[ssible] fluid.

The hydrostatic, or water press, as it is sometimes called, was first b[rought] into a practical form by the late Mr. Joseph Bramah, and was patented b[y him] in 1796. Since this period it has undergone many new improvements [in the] constructive department, which, although they have not sensibly added [to its] mechanical energy, have materially added to its convenience, by render[ing its] operation more easy and certain. The following diagram is explanatory o[f the]



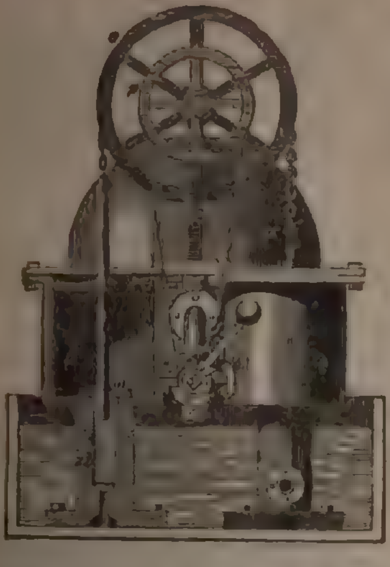
principle upon which it acts. *a* represents the foundation plate of the ma[chine], and *b* the head-plate, connected together by four strong standards *c c*; the[se] should be of wrought iron; and the whole of the utmost strength and solid[ity to] resist the entire force of the press, which is exerted upon the goods placed be[tween] the follower *d* and the head of the press. The piston or ram *e*, (which sup[ports] the follower and goods) moves up and down in a very massive hollow cyl[inder] *f f*, bored very accurately at its upper part to fit the ram, and at its low[er] somewhat widened, as shown by the dotted lines, to admit a small quan[tity of] water, which is forced into it by a small force-pump *g*, along the pipe *h*. [Just] above that part of the cylinder where the water discharges itself in a [...] crevice, an annular cavity is formed around the cylinder, wherein is [a] folding collar of leather, which presents a thin edge both to the ram and t[he] cylinder, to render the junction between them water-tight, which it does [most] effectually by the action of the pressure itself. The top of the cylinder [where] the ram emerges from it, is provided with a stuffing box, well packe[d and] secured by a covering plate. Now if we suppose the area of the valve by [which] the water is admitted into the cylinder to be one-eighth of an inch (as [...] and the power applied thereto by the lever of the pump to be a ton, a[nd the] area of the section of the ram to be 64 inches, we have 64 × 64 = [...] tons applied to the goods in this press, according to the known laws [of the] pressure of fluids, as explained under the article HYDROSTATICS. The [power] mentioned is unnecessarily great for the general purposes of a press; bu[t ...]

... that it may be reduced to any required extent by altering the propor-... f the lever, the valve of transmission, and the ram; and it is equally ... that the power may, by other modifications, be increased to an indefinite ...

...ould, however, be noticed, that in the hydrostatic press of Bramah, in ...n use, the same time is occupied in pumping against a small, as against ... resistance: in almost all cases the operation is commenced when the ...nce is at a minimum: during the process the increase is gradual, and at ...mination the resistance is at a maximum. As a remedy for this practical ...nience, hydrostatic presses are generally made with two levers of different ..., with the view of changing the power at some time during the process. ...standing this provision, however, the time and trouble attending the ..., renders its assumed advantages a doubtful question of economy, and it ...equently, rarely resorted to in practice.

...bviate these objections, Mr. James Murdoch has proposed a self-regulating ...atic press, in which the change of power proceeds in the same ratio as ...stance, without any care or interference on the part of the operator. ...genious arrangement proposed will be comprehended by the annexed ...s, marked *Fig.* 1 and *Fig.* 2, together with the following description:—

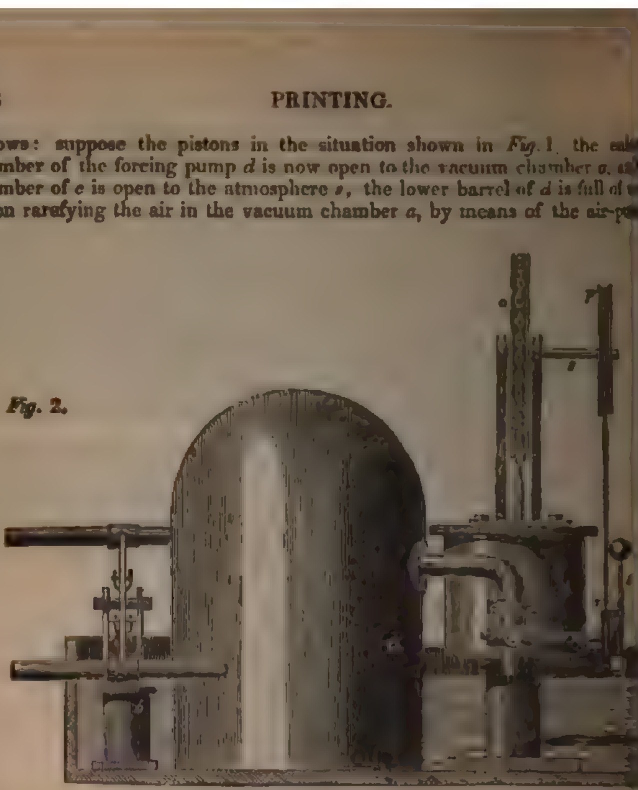
...1.



...ents the vacuum chamber, being similar to the exhausted receiver of an ...p: *b* a double-barrelled air-pump; *c* a four-way cock, connecting *a* ... and *e*, the two force pumps, and its lower end communicating with the ...ere; *d* is a section of one of the force pumps; *f* is the plunger, working ... the stuffing-box *m*, and having a solid piston *h* keyed on to it, which ...air-tight in the enlarged part of *d*; *g* is a valve opening upwards; *n* the ...e, leading to the press, which is not here shown, it being of the usual ...ction; *o* is a wheel, over which passes a chain connecting the two ...; it is fixed square on the axle *t*, as is the wheel *p*, which serves to ... cock by means of a cord passing round it and *r*, which is a pulley ... loose on *c*, and having a projecting shoulder on its lower part; *s* is a ...d square on *w*, having shoulders at its lower end, and a weight at its ...d; *v* is a rod attached to the plug of the cock *c*. The action is as

follows: suppose the pistons in the situation shown in *Fig.* 1, the ... chamber of the forcing pump *d* is now open to the vacuum chamber *a*, ... chamber of *e* is open to the atmosphere *s*, the lower barrel of *d* is full of ... Upon rarefying the air in the vacuum chamber *a*, by means of the air-p...

Fig. 2.



the air in the chamber *d* likewise becomes rarefied, and the piston *h* will d... as soon as the pressure on it exceeds the pressure on the plunger *f*, and a ... of water is thus forced into the press by the pipe *n*. By the descent ... piston *h*, the wheel *o* revolves, and brings up the piston of the chamber ... smaller wheel *p* is carried round at the same time, and turns the ... the shoulder on which, taking the shoulder on *s*, carries it round a litt... the vertical line, when it (*s*) falls into the position of the dotted line, and ... *e* to the vacuum chamber, and *d* to the atmosphere. The air under the ... of *e* now becomes rarefied, and it descends in like manner as the other. ... larger the vessel *a* is made in proportion to the chambers *d* and *e*, the ... will the press accommodate itself to the changes of resistance.

Printing presses are described under the article Printing: see als... Copying-machine, &c.

PRINTING. The art of taking copies by impression of type, en... plates and blocks, or of any design or work whatever, in black-ink or pi... of various colours; but the word *printing*, standing alone, without any dis... addition, is usually understood to imply typography, or printing from ... usually called letter-press printing, which we propose to notice in th... place.

It is a remarkable circumstance, that notwithstanding the art of lette... printing has formed a new era in the history and character of our speci... origin of its invention is involved in mysterious obscurity. The pr... honour of having given birth to this sublime vehicle of knowledge ha... claimed by the Italian, the German, the Dutch, and the Swiss nations. ... inhabitants of Mentz, Strasbourg, and Haerlem, seem to have the mo... ground for their boastings; but we are bound to state, that the citiz... Venice, Rome, Florence, Basle, Augsburg, and Dordrecht, certify to the ... trary thereof. The discussion of this interesting question not accordi... the nature of our work, we recommend those of our readers who are ...

ormation upon the early history of the art, to the article PRINTING, in the *Encyclopædia*. We may, however, observe, that it seems to be admitted parties that this invention took place about the year 1440, and was brought land by William Caxton, who set up his first press in Westminster Abbey, gan to print books some time after the year 1471. In the early stages of the impressions were taken off with a list coiled up, such as the card- use at this day; but when they came to use single types, they employed paper, with vellum and parchment. At last the press was introduced, ought gradually to its present state. The same observation applies to the first the common writing ink was employed; and the printing ink of lack and size, and lamp-black and oil (that now used) were introduced rees. We shall now proceed to explain the printer's art, as it is prac- the present day; premising that it is divided into two branches, tion, or the arrangement of the types, and *press-work*, or the taking off ions from types so arranged: the workmen employed are therefore dis- hed into two classes,—"compositors" and "pressmen." Each compositor at a sort of desk, called a frame, and, in most instances, he has a desk or to himself. The frames project laterally from the wall. At intervals re large tables, with stone tops, technically called imposing-stones. ame at which a compositor works is constructed to hold two pair of each pair of cases contains all the letters of the alphabet, whether small r capitals, as well as points, figures, &c. &c. One of these pair of cases ed by the Roman letters, the other by the Italic. The upper case is into ninety-eight partitions, all of equal size; and these partitions con- sets of capital letters, one denominated "full capitals," the other s;" one set of figures, the accented vowels, and the marks of reference . The lower case is divided into partitions of four different sizes; some op and ends being a little smaller than the divisions of the upper case; nearer the centre, being equal to two of the small divisions; others equal , and one equal to six; in all there are fifty-three divisions in the lower The inequality in the size of the cells in the lower case is to provide great differences as to the quantity required of each letter. According language in which it is used, one letter is much more wanted than , and the proportions required of each have been pretty accurately by long experience. As some of our readers may be curious to know proportions, as they apply to the English language, we subjoin the unders' scale for the small characters of a fount of letter, of a particular d weight:—

a	8,500	n	8,000
b	1,600	o	8,000
c	3,000	p	1,700
d	4,400	q	500
e	12,000	r	6,200
f	2,500	s	8,000
g	1,700	t	9,000
h	6,400	u	3,400
i	8,000	v	1,200
j	400	w	2,000
k	800	x	400
l	4,000	y	2,000
m	3,000	z	200

portion in which a particular letter is required renders it necessary that of the lower case should be arranged, not as the letters follow each, ically, but that those in most frequent use should be nearest the hand ompositor. The point to which he brings the letters, after picking them f their cells, is not far removed from the centre of the lower case; n a range of about six inches on every side he can obtain the , e, m, n, h, o, p, u, t, a, and r, the letters in most frequent use. The

spaces, which he wants for the division of every word, lie close at his hand, the bottom of the central division of the lower case. It must be quite obvious that the man who contrived this arrangement saved a vast deal of time to the compositor.

The cases, particularly the upper one, are placed in a sloping position, that the compositor may the more readily reach the upper boxes. The instrument in which the letters are set is called a composing-stick, which consists of a long and narrow plate of iron, brass, or other compound metal, on the right side of which arises a ledge, which runs the whole length of the plate, and serves to sustain the letters, the sides of which are to rest against it; along this ledge is a row of holes, which serve for introducing the screw, in order to lengthen or shorten the extent of the line, by moving the sliders farther from, or nearer to the shorter ledge at the end. Where marginal notes are required in a work, the two sliding pieces are opened to a proper distance from each other, in such a manner as that, while the distance between forms the length of the line of the text, the distance between the two sliding-pieces forms the length of the line for the notes on the side of the page.

Before the compositor proceeds to compose, he puts a rule or thin slip of brass-plate, cut to the length of the line, and of the same height as the letter, in the composing-stick, against the ledge, for the letter to bear against. Thus prepared, the compositor having the copy before him, and his stick in his left hand, his thumb being over the slider; with the right hand he takes up the letters one by one, and places them against the rule, while he supports them with his left thumb by pressing them to the end of the slider, the other hand being constantly employed in setting in other letters, which is effected by a skilful workman at an average rate of about thirty per minute. A line being thus composed, if it end with a word or syllable, and exactly fill the measure, there needs no further care; otherwise more spaces are to be put in, or else the distance lessened between the several words, in order to make the measure quite full, so that every line may end even. The spaces here used are pieces of metal exactly shaped like the shanks of the letters; they are of various thicknesses, and serve to preserve a proper distance between the words; but not standing so high as the letters, they make no impression when the work is printed. The first line being thus finished, the compositor proceeds to the next; in order to do which he removes the brass rule from behind the former, and places it before it, and then composes another line against it after the same manner as before; going on thus till his stick is full, when he empties all the lines contained in it into what is called a galley, which consists of a flat piece of mahogany, or other fine wood, with a ledge of a proper height at the margin of its two sides. The compositor then fills and empties his composing-stick as before, till a complete page is formed; when he ties it up with a cord, and, setting it by, he proceeds to the next, till the number of pages constituting a sheet is completed; which done, he carries them to the imposing-stone, there to be ranged in order, and fastened together in a frame called a chase,—and this is termed imposing. The chase is a rectangular iron frame, of different dimensions, according to the size of the paper to be printed, having two cross-pieces of the same metal, called a long and short cross, mortised at each end, so as to be taken out occasionally. By the different situations of these crosses, the chase is fitted for different volumes; for quartos and octavos one traverses the middle lengthwise, the other broadwise, so as to intersect each other in the centre; for twelves and twenty-fours, the short cross is shifted nearer to one end of the chase; for folios, the long cross is removed entirely, and the short one remains in the middle; and for broadsides, no cross is required. To impose, or arrange and fix the pages in the chase, the compositor makes use of a set of furniture, consisting of slips of wood of different dimensions, somewhat lower than the letter; some of these are placed at the top of the pages, and called head-sticks, others between them, to form the inner margin; and others, in the form of wedges, at the sides and bottoms of the pages. Thus all the pages being placed at their proper distances, and secured from being injured by the chase and furniture placed about them, they are all untied, and fastened together by driving

wedges of wood, called quoins, between the slanting side of the foot and ...sticks and the chase, by means of a piece of hard wood and a mallet; ...being thus bound fast together, so that none of the letters will fall out, ...dy to be committed to the pressmen. In this condition, the work is ... form; and as two of these forms are in most cases required for every ... it is necessary the distances between the pages in each form should be ... with such exactness, that the impression of the pages in one form shall ...tly on the back of the pages of the other; the effecting this is called ... register.

...is impossible but that there must be some mistake in the work, either ... the oversight of the compositor, or by the casual transposition of letters ... cases, a sheet is printed off, which is called a proof, and given to the ...or, who, after reading it over, and rectifying it by the copy, making the ...ons in the margin, returns it to the compositor to be corrected. The ...itor then unlocking the form upon the correcting stone by loosening the ...er wedges, rectifies the mistakes by picking out the wrong letters with a ... sharp-pointed steel bodkin, and putting others into their places. After ...other proof is made, and corrected as before; and lastly, there is another ...alled a revise, which is taken from the form when finally placed on the ... in order to ascertain whether all the mistakes marked in the last proof ...een corrected.

...*pressman's* business is to work off the forms thus prepared and corrected ... compositor; in doing which, there are four things required—paper, ink ...uring matter, balls or rollers, and a press.

...prepare the paper for use, it is to be first wetted by dipping several sheets ... in water; these are afterwards laid in a heap over each other; and to ...hem take the water equally, they are pressed close down with a weight ...top.

... ink is made of oil and lamp-black; for the manner of preparing which, ...

... balls, by which the ink was formerly applied on the forms, were a kind ...den funnels with handles, the cavities of which were filled with wool or ... was also a piece of leather or pelt nailed over the cavity, and made ...ely soft by soaking in urine, and being well rubbed. One of these the ...an took in each hand, and applying one of them to the ink-block, daubed, ...ked them together, to distribute the ink equally, and then blacked the ... which was placed on the press, by beating with balls upon the face of ...ter. A considerable improvement on this plan has been effected by means ...ers, which are now generally in use. These consist of a cylinder made ...mbination of treacle and glue, which runs on an iron rod, affixed to which ... handles. Instead of beating, as in the former case, the cylinder is ... over the face of the form, by which the ink is applied in a much more ...anner, and with a considerable decrease of labour.

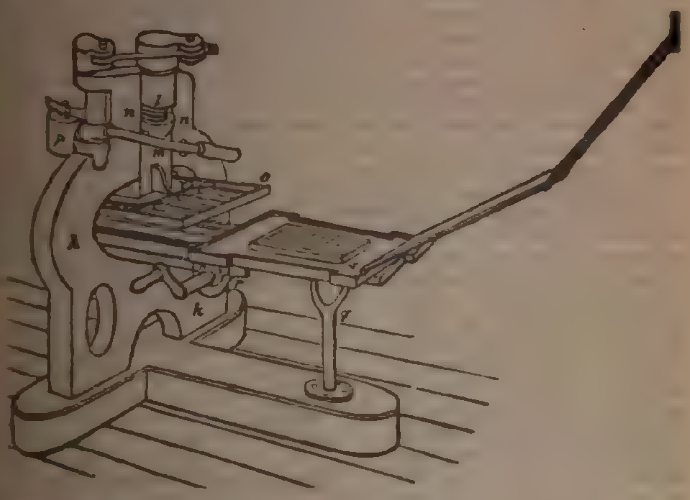
... earliest printing presses were the common large wooden screw presses, ...yed at the present day for compressing paper, cloth, &c. Of course this ... of taking impressions must have been very slow and laborious; and the ...e being applied between the two solid inelastic surfaces, a considerable ... of care must have been exercised to prevent injury to the letters or type ... form. Such presses were, however, used for about 300 years, without ... attempting to improve them. A short time previous to the year 1770 ...was that William Jansen Blaew, a mathematical instrument maker, of ...dam, recommended the introduction of a spring, both over the head and ... the bed of the press, which, upon trial, proved very satisfactory; he took ...himself an alteration of the working screw, giving it more threads, which ...ffect, a quicker motion; and this, combined with the action of the springs, ...d the impression "sharper," without "hardness." Blaew's presses were ... to be so great an improvement upon their precursors, that Luckcombe, in ...*History of Printing*, published in 1770, says, "There are two sorts of ... in use, the old and the new fashioned; the old sort, till of late years, ...e only presses used in England." Now the "new-fashioned" press of

Blaew, though it has become very old-fashioned to modern print respectable a machine, in our eyes, to be wholly omitted in these pages; differs not in any considerable degree from the wooden-framed presses by many of our printers, we shall here annex a description which will apply to them both. It consists of two upright beams, called cheeks, feet long, tenoned into a cap above, and, at their lower ends, into a sto frame, on which it stands. The head of the press is sustained by bolts, that pass through the cap. A screwed nut is fixed in the head, which the screw works when operated upon by the lever; the low mity of this screw is called the spindle, which is a cylindrical piece working in a metallic cup of oil, fixed to an iron plate let into the top of solid, and thick piece of mahogany, whose surface is brought to a smooth plane, and is called the platten. This platten, by pulling the made to descend and press upon a blanket, which covers the paper the form of types, and thereby produces an impression. The form is a broad flat stone, or thick marble slab, which is let into a wooden fram a coffin; this coffin is fixed upon a carriage, which is made to run upo zontal railway under the platten for an impression, and out clear of t to take off the printed sheet, and put a blank one in its place. This and forward motion of the carriage and form is produced by a strap and turned by a winch handle. The paper is adjusted and held down by a frame, called the tympan and frisket, which again fold down over the fr type, in a very exact manner, before the form is run in under the p receive an impression. By presses of this kind, about 250 impressions off in an hour; in light work it is extended to 300 in an hour; an presses of this kind were used for printing newspapers, the printers by extraordinary efforts and relays of men, to work as many as the hour.

The principal defect in the common or old fashioned press just described in the effective power of the lever being uniform throughout its range o requiring the pressman to exert his bodily strength to the utmost, in giv tug at the end of the pull; at which time only, when the platten is do the form, great force becomes necessary. This disadvantage is co obviated in the improved press invented by the late patriotic Earl S which machine we purpose describing after having explained the upon which its chief excellence depends, namely, the combination of le which the platten is forced down upon the form of types. In the annexed diagram $a\,b$ represents a short lever, which is connected to the top of the screw which carries the platten, the shorter arm of the said lever being the radius of the screw; its longer arm the distance between the centre of the screw to the point b. This lever, by means of a connecting rod c, acts upon the bent lever $d\,e\,g$, whose fulcrum is at e; and as, by this combination of the lever, the platten acts but through a small space in comparison to the space passed through by the power, it follows that the effect must be very powerful. But it is necessary that this effect should be at a maxim the platten impinges upon the type, and this object is accomplishe angular position of the levers; for when the platten is elevated, the le parallel to the line $h\,i$, and its shorter arm $e\,d$ is nearly perpendicul same line, and also the connecting rod c; therefore will move the rod greatest velocity during the first part of the motion of the lever $e\,g$; time the lever $a\,b$ forms an acute angle with the line $h\,i$; consequ

a disadvantage in causing the revolution of the screw; but by the time the lever *e g* is brought perpendicular to the line *h i* (when the platten impinges upon the type) the lever *a b* is also perpendicular to the connecting rod *c*; consequently it will then exert its greatest influence in causing the revolution of the screw, and at this time also the power of the workman will be applied at right angles to the lever *e g*, therefore will produce the greatest effect precisely at the moment of impact.

The "Stanhope press" is, in other respects, a considerably improved machine. The whole frame is made of one massive iron casting, as represented at *k k* in the subjoined cut, which exhibits a perspective view of it. In the upper part of the machine a nut is fixed, into which a stout, well

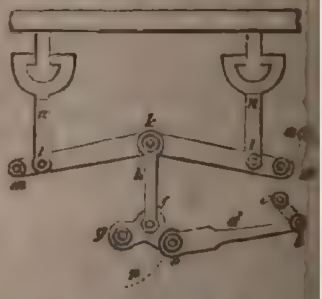


cut screw *l* works, having a conical end that operates upon the upper end of a slider *m*, which is fitted into a dovetailed groove formed between two vertical bars *n n* of the frame. The slider has the platten *o* firmly attached to the lower end of it; and being accurately fitted in the guide bars *n n*, the platten rises and falls parallel to itself, when the screw *l* is turned. The weight of the platten and slider is counterbalanced by a heavy weight *p*, which is suspended from a lever, that acts upon the slider to lift it up, and keep it always bearing against the point of the screw. At *q* is a forked support to the railway and carriage. The carriage is moved by a winch or "rounce," with a "spit" and leather straps, which pass round a pulley *r*, one strap extending to the back of the carriage to draw it in, and two others pass round the wheel in an opposite direction, to draw it out: *s* is the table on which the type is laid. The combination of levers in this machine, it will be observed, is precisely the same as in the preceding diagram, and their action is the same; consequently further description of them is omitted.

The superiority of iron presses over the wooden ones may, in a great measure, be attributed to the extreme accuracy with which the corresponding surfaces of the platten and table are levelled. This is effected by turning them in the lathe, with a slide-rest; and this is performed with such precision that if they do not bite a hair or a thin piece of paper in every part, they are not considered to be finished. The advantage of true workmanship must be apparent in printing such surfaces as those of our large newspapers, and clearly bringing up every letter and dot out of perhaps a hundred thousand or more.

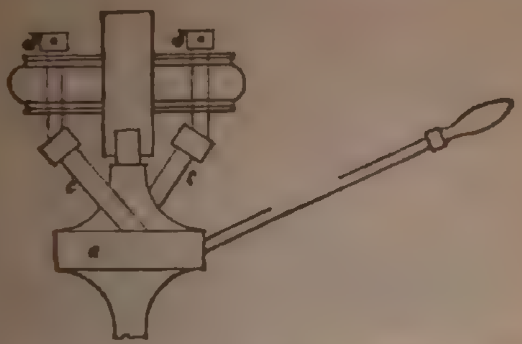
Numerous alterations have been successively made upon the Stanhope p the manufacturers, who magnify them to the public as being vast improv as increasing the productive power of the press in a duplicate and even t ratio; but our mechanical readers will at once perceive the impossibili correctness of such statements: that if there be a loss of ten or fifteen p of the power applied to the Stanhope press, arising from friction, &c., n fication whatever of the six mechanical agents can save the whole of t The press may be rendered more convenient and handy, and the minor a ments and appendages may be also improved; indeed, we doubt not th ameliorations have been and will continue to be introduced; but they perfectly insignificant and trifling when compared with the beautiful in of the patriotic Stanhope. Amongst the ablest manufacturers of the day of iron presses, we may mention Messrs. Ruthven, Medhurst, Sherwin, Clymer; there are many others, we doubt not, of equal abil have not succeeded in making themselves as well known. All the pre we have from time to time seen, and especially those of the manufactu have named, possess some peculiar points of excellence as well as de their mechanism, to describe and discuss which would take up much t space. In justice, however, to the two first-named gentlemen, whose in possess great originality and simplicity, we must afford room for a comp notice of the peculiar contrivances which distinguish them from all oth

In 1813 Mr. Ruthven, of Edinburgh, took out his patent, which term expired, the invention is public property. Instead of placing the types the case in all previous inventions, upon a movable carriage, they are fix a stationary table, and the platten and tympans are drawn over it, impression is effected by a system of levers, the action of which the diagram will serve to explain. *a c b* is an angular lever, whose longer arm *a c* is in the form of a winch, to which the workman applies his power; while the shorter arm *c b* acts upon the extremity of the connecting rod *d*, by which its efficacy is transmitted to the point *e* of the lever *e f*, whose fulcrum is at *g*; this lever is connected by the rod *h* to the extremities of the levers *k l m*, whose fulcra are *m m*. The rods *n n* are connected with the levers *k l m* at *l l*, while their upper ends act upon the support of the platten by means of a species of hooks. Now if the lever or w be turned in the direction of the dotted line *a o*, the shorter arm *c b* w the rod *d* in the direction *b e*; consequently the point *e* of the lever *e* move in the direction of the dotted line *e p*; and as the point *f* will de similar arch, the rod *h* will depress the ends *k* of the levers *k l m*; t the rods *n n* will be drawn down, bringing with them the platten. Th regulation with regard to the angular positions of the levers is observed beautiful arrangement as in the Stanhope, so that their greatest efficacy is at the moment of impact.



Mr. Medhurst's press, except in the mechanism by which the power municated to the platten, resembles those in general use; but in that r forms a very remarkable exception; no screw is used: but the spindle t the platten is made fast is swelled out at its upper end into a bro collar, as shown at *a* in the following cut, into which the lever or han the press is inserted. At equal distances apart on the upper side of this collar are turned out of the solid two steps or cups, which receive the two inclined bolts *c c*, which bolts are supported at their upper ends points of two screw-bolts *d d*, that pass through the head *e*, and enter

...le in the heads of *e e*. When the platten is up, the rods *e e* lean in the ...lined position, as shown; but when the spindle is turned a quarter of a revo-



...tion, the bolts *e e* take a vertical position, and as the head *e* is immovable, the ...llar *a* on the spindle is forced down, and with it the platten to which it is ...tached.

Prior to the introduction of printing machines, the press department was one ...great labour, whenever extraordinary expedition was required. It was par-...ticularly the case with newspapers, of which, with the utmost exertions, scarcely ...ever more than 750 copies could be obtained in an hour: the consequence was, that in newspaper offices where the circulation was extensive, it was found ...necessary, in order to get the paper published in time, to compose two or more ...copies; so that, by going to press at the same time, the demands of the public might be complied with, thus occasioning an enormous increase of expenditure ...both in the compositors' and press department. In a newspaper circulating ...or 8000 copies, this expense amounted annually to at least 2000*l.*, all of which ...has been saved by the introduction of machines.

In the 3d vol. of the *Quarterly Journal of Science* (new series) is inserted a ...communication "on the recent improvements in the art of printing," by Mr. Cowper, a gentleman of extensive information upon every thing relating to the subject, who has invented many important improvements in the mechanism and process of the art, both individually, and in conjunction with his partner, Mr. Applegath, and who is therefore eminently qualified to give a correct ...statement of the facts, which we shall subjoin, slightly abbreviated from the ...original. The little diagrams that are inserted in the body of the text serve to explain, in a very clear and concise manner, the leading principle or arrange-...ments of the successive inventions described, respecting which it is also neces-...sary to observe, that—

The black parts in every figure	represent		the inking apparatus.
The diagonal lines	"	"	the paper cylinders.
The perpendicular lines	"	"	the types or plates.
The arrows	"	"	the track of the sheet of paper.

It was in the year 1790 that Mr. William Nicholson took out a patent for ...certain improvements in printing; and, on reading his specification, every one ...must be struck with the extent of his ideas on the subject: to him belongs, ...beyond doubt, the honour of the first *suggestion* of printing by means of ...cylinders; the following are his own words, divested of legal redundancies:—

"In the first place, I not only avail myself of the usual methods of making ...types, but I do likewise make and arrange them in a new way, viz. by ren-...dering the tail of the letter gradually smaller; such letter (he says) may be

imposed on a cylindrical surface; the disposition of types, plates, and blocks, upon a cylinder, are parts of my invention.

"In the second place, I apply the ink upon the surface of the types, plates, &c. by causing the surface of a cylinder, smeared with colouring matter, to roll over, or successively apply itself to the surface of the types, &c., or else I cause the types to apply themselves to the cylinder. It is absolutely necessary that the colouring matter be evenly distributed over this cylinder, and for this purpose I apply two, three, or more smaller cylinders, called distributing rollers, longitudinally against the colouring cylinders, so that they may be turned by the motion of the latter; if this colouring matter be very thin, I apply an even blunt edge of metal or wood against the cylinder.

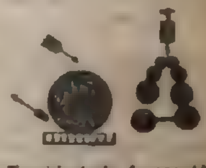
"In the third place, I perform all my impressions by the action of a cylinder, or cylindrical surface; that is, I cause the paper to pass between two cylinders, one of which has the form of types attached to it, and forming part of its surface, and the other is faced with cloth, and serves to press the paper so as to take off an impression of the colour previously applied; or otherwise, I cause the form of types, previously coloured, to pass in close and successive contact with the paper wrapped round a cylinder with woollen cloth." He also described a method of raising the paper cylinder, to prevent the type from soiling the cloth.

Nicholson's arrangement for arched type.

Nicholson's arrangement for common type.

These words specify the principal parts of modern printing machines; and had Mr. Nicholson paid the same attention to any one part of his invention which he fruitlessly devoted to attempting to fix types on a cylinder, or had he known how to curve stereotype plates, he would, in all probability, have been the first *maker* of a printing machine, instead of merely suggesting the principles on which they might be constructed.

The first working printing machine was the invention of Mr. T. Koenig, a native of Saxony; he submitted his plans to Mr. T. Bensley, the celebrated printer, and to Mr. R. Taylor, the scientific editor of the *Philosophical Magazine*. These gentlemen liberally encouraged his exertions, and in 1811 he took out a patent for improvements in the common press, which, however, produced no favourable result. He then turned his attention to the use of a cylinder, in order to obtain the impression, and two machines were erected for printing the Times newspaper, the reader of which was told, on the 28th of November, 1814, that he held in his hand a newspaper printed by machinery, and by the power of steam.



Koenig's single, for one side of the sheet.

In these machines the type was made to pass under the cylinder, on which was wrapped the sheet of paper, the paper being firmly held to the cylinder by means of tapes; the ink was placed in a cylindrical box, from which it was forced by a powerful screw, depressing a tightly-fitted piston; thence it fell between two iron rollers: below these were placed a number of other rollers, two of which had, in addition to their rotatory motion, an end motion, that is, a motion in the direction of their length; the whole system of rollers terminated

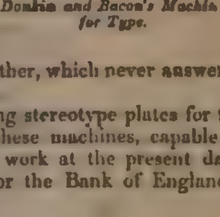
or two, which applied the ink to the types. In order to obtain a great number of impressions from the same form, a paper cylinder (*i. e.* a cylinder in which the paper is wrapped) was placed on each side of the inking apparatus, the form passing under both. The machine produced 1100 impressions per hour; subsequent improvements raised them to 1800 per hour.

The next step was the invention of a machine (also by Mr. Koenig) for printing both sides of the sheet: it resembled two single machines, placed with their cylinders towards each other, at a distance of two or three feet. The sheet was conveyed from one paper cylinder to the other by means of tapes; the track of the sheet exactly resembled the letter S, if laid horizontally, thus, ∽. In the course of this track the sheet was turned over. At the first paper

Koenig's Double Machine, for printing both sides of the Sheet.

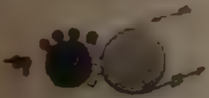
cylinder it received the impression from the first form, and at the second paper cylinder it received the impression from the second form; the machine printed 750 sheets, on both sides, per hour. This machine was erected for Mr. T. Bensley, and was the only one Mr. Koenig made for printing on both sides the sheet: this was in 1815.

About this time Messrs. Donkin and Bacon were also contriving a printing machine; having in 1813 obtained a patent for a machine in which the types were placed upon a revolving prism; the ink was applied by a roller, which rose and fell with the irregularities of the prism; and the sheet was wrapped on another prism, so formed as to meet the irregularities of the type prism. One of these machines was erected for the university of Cambridge, and was a beautiful specimen of ingenuity and workmanship. it was, however, too complicated, and the inking was defective, which prevented its success. Nevertheless, a great point was attained; for in this machine were first introduced inking-rollers, covered with a composition of treacle and glue; in Koenig's machine the rollers were covered with leather, which never answered the purpose well.



Donkin and Bacon's Machine for Type.

In 1815 Mr. Cowper obtained a patent for curving stereotype plates for the purpose of fixing them on a cylinder. Several of these machines, capable of printing 1000 sheets per hour on both sides, are at work at the present day; and twelve machines on this principle were made for the Bank of England a short time previous to the issue of gold.



Cowper's single, for curved Stereotype.

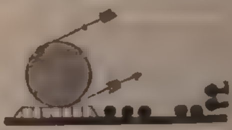
Cowper's double, for both sides of sheet.

It is curious to observe that the same object seems to have occupied the attention of Nicholson, Donkin and Bacon, and Mr. Cowper, viz. the revolution

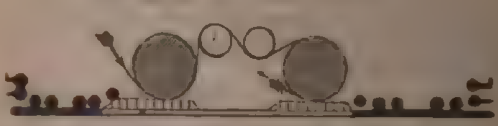
of the form of types. Nicholson sought to do this by a new kind of type shaped like the stones of an arch. Donkin and Bacon sought to do this by fixing types on a revolving prism; and at last it was completely effected by the curving of a stereotype plate by Mr. Cowper.

In these machines two paper cylinders are placed side by side, and against each of them is placed a cylinder for holding the plates; each of these four cylinders is about two feet diameter; on the surface of the plate cylinder are placed four or five inking-rollers, about three inches diameter; they are kept in their position by a frame at each end of the plate cylinder, the spindles of the rollers lying in the notches on the frame, thus allowing perfect freedom of motion, and requiring no adjustment. The frame which supports the inking-rollers, called the waving-frame, is attached by hinges to the general frame of the machine; and the edge of the plate cylinder is indented, and rubs against the waving-frame, causing it to wave or vibrate to and fro, and, consequently, to carry the inking-rollers with it, thus giving them a motion in the direction of their length, called the end motion. These rollers distribute the ink upon three-fourths of the surface of the plate cylinder, the other quarter being occupied by the curved stereotype plates. The ink is held in a trough; it stands parallel to the plate cylinder, and is formed by a metal roller revolving against the edge of a plate of iron; in its revolution it becomes covered with a thin film of ink; this is conveyed to the plate cylinder by an inking-roller vibrating between both. On the plate cylinder the ink becomes distributed as before described, and as the plates pass under the inking-rollers they become charged with colour; as the cylinder continues to revolve, the plates come in contact with a sheet of paper in the first paper cylinder, whence it is carried, by means of tapes, to the second paper cylinder, where it receives an impression on its opposite side from the plates on the second plate cylinder, and thus the sheet is perfected. These machines are only applicable to stereotype plates, but they formed the foundation of the future success of Applegath and Cowper's printing machinery, by showing the best method of furnishing, distributing, and applying the ink.

In order to apply this method to a machine capable of printing from type, it was only necessary to do the same thing in an extended flat surface or table, which had been done on an extended cylindrical surface; accordingly Mr. Cowper constructed a machine for printing both sides of the sheet from type, securing by patent the inking apparatus, and the mode of conveying the sheet from one paper cylinder to the other by means of drums and tapes.



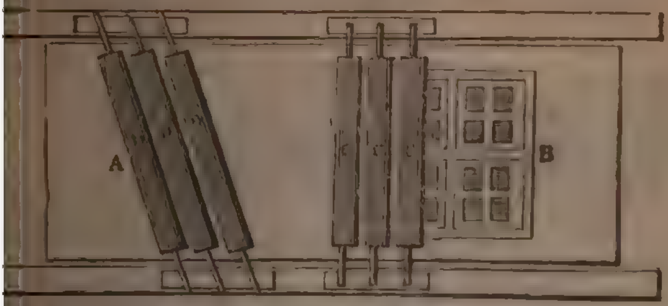
Applegath and Cowper's Single Machine.



Applegath and Cowper's Double Machine.

Mr. A. Applegath, who was a joint proprietor with Mr. Cowper in these patents, obtained patents for several improvements. Mr. Cowper had given the end motion to the distributing rollers by moving the frame to and fro in which they were placed. Mr. Applegath suggested the placing of these rollers in a diagonal position across the table, thereby producing their end motion in a simpler manner,—a plan of which we subjoin. A is the inking table or the

…, on which the ink is spread and distributed; B is the form of types; …are the rollers for communicating the ink to the types; D D D are the …ating rollers placed diagonally across the table, their pivots resting in … the carriages. The table is made to slide backward and forward, causing … motion the rollers to revolve, which are nicely adjusted in contact with …ble, so as to press evenly on the surface of it, those in the oblique position



Applegath's Patent Inking Table.

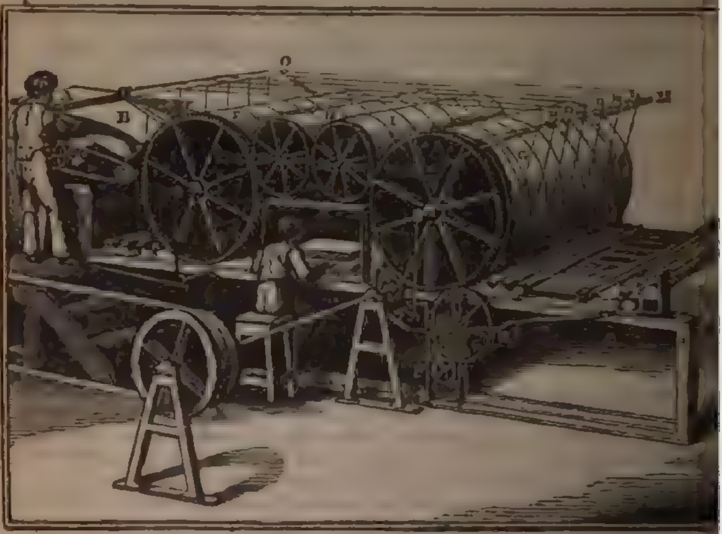
…g the ink upon the surface to be *spread* out very evenly, so that the … C C C, which follow in action, become charged very uniformly, and …t it to the type in like manner. The diagonal rollers must have an …ble tendency to spread out the ink in a smooth stratum, by the sliding of …le in a different direction to the lines of revolution; but there must be …rable friction at their axes by the constant tendency of the table to …the rollers sideways or endways, which must be provided against, or they …on wear untrue. He also contrived a method of applying two feeders to the …rinting cylinder; these latter inventions are more adapted to newspaper … book-printing. Numerous machines have been constructed upon the …ventions of Messrs. Applegath and Cowper, which are modified in a great … of ways for the various purposes of printing books, bank-notes, news…, &c.; they have, in fact, superseded Mr. Koenig's machines in the office … Bensley (who was the principal proprietor of Koenig's patent), and also … office of the *Times*, as was announced in that journal. No less than forty … were removed from Koenig's machines when Mr. Bensley adopted the …vements of Messrs. Cowper and Applegath. Having, on the first trial of …achines, discovered the superiority of the inking-roller and table over the …n balls, they immediately applied …to the common press, and with com…success, the invention, however, was …ately infringed throughout the king…and copied in France, Germany, and …ca; and it would have been as … to have attempted to stop the …ement of the patent as it was found … case of the kaleidoscope. This …ion has raised the quality of printing

…ly. In almost any old book will be perceived groups of words very …and other groups very light; these are technically called "monks and …," which have been reformed altogether. The principal object in a news…machine is to obtain a great number of impressions from the *same* form, … side of the sheet, and not from *two* forms, or both sides of the sheet, as ….

…he *Times* machine, which was constructed on the joint invention of …. Applegath and Cowper, the form passes under four printing cylinders,

which are fed with sheets of paper by four lads, and, after the shee
printed, they pass into the hands of four other lads; by this contrivance
sheets per hour are printed on one side.

The annexed engraving affords a general or perspective view of
Messrs. Cowper and Applegath's double machines, constructed on the



ciple of the diagram on page 346. A boy is represented as standing
platform, with a pile of paper A on a table on his left hand, from wh
has taken a sheet of paper B, and is applying it to the machine.
goes under the cylinder F, and is there printed on one side, it is
conducted over the intermediate cylinders H I, on to the cylinder G, p
round this, and underneath; the sheet of paper is thereby turned w
opposite side against the type, and receives the second or finishing im
sion, and is then conducted to the top of the pile of printed sheets,
a boy at Z is shown sitting on a stool, and receiving the sheets as
are presented, and laying them square on the pile before him. The
forms of types designed to print both sides of the sheet, are placed a
requisite distance asunder, upon one long bed mounted on a carr
which is moved backwards and forwards upon a railway, constructed to
the carriage, with great accuracy, into contact with the cylinders F and
produce the impression. The reciprocating motion of the carriage is ef
by a pinion fixed upon the end of a vertical spindle, taking into the teeth
endless rack, which is connected by a system of levers with the type car
in such a manner, that when the pinion is turned round, it engages, at alte
periods, in the teeth formed on the opposite sides of the rack, and consequ
on the opposite circumference of the pinion: thereby a continuous mot
the pinion communicates a reciprocating motion to the rack and carriage.
vertical spindle is turned by a couple of bevelled wheels, from the pinio
which receives its motion by an intermediate wheel Q from the toothed
upon the end of the main cylinder G. An inking apparatus is situated at
end of the machine. At N one of these is brought into view; it consist
cylindrical metal roller, which has a slow rotatory motion, communicated to
a catgut band passing round a small pulley upon the end of the axis of the

G. The roller at N is adapted to carry down a thin film of ink upon its ference, by turning in contact with a mass of ink disposed upon a hori-plate of metal, the edge of which plate is ground straight, and the dis-tween the two surfaces is adjusted by screws. Upon an axis turning mounted a composition roller, connected by cranked levers with a small circle fixed upon the end of the axis of the cylinder g, causing it to und the axis P, and remain for a short period in contact with the face ink-roller N, thereby receiving a portion of ink upon its surface: it scends and rests with its whole weight upon the surface of the table, affixed to the end of the type carriage, the reciprocating motion of causes the ink-table to receive ink upon its surface from the elastic roller mentioned. In this situation, when the type-carriage returns, the surface ble is made to pass under three elastic rollers; these rollers are mounted ivots in a frame, in such manner that they have liberty to move some-and down, in order that the rollers themselves may bear severally upon face of the table; and to equalize the ink perfectly over the table, an tion is given to the rollers by means of inclined planes, against which e into contact; and by the further motion of the type-carriage, the ink-caused to pass under four other small elastic rollers, which in like manner h their weight upon the surface of the table, and thereby take up the n their circumferences, which they impart to the types as the form backwards and forwards under them, thus touching every type eight Whilst this operation of inking the types is going on at one end of the e, the printing process is performed at the other end on one of the sides heet from the types last inked, and *vice versâ*.

improvements in printing machinery, patented by Mr. Wayte, a printer, nt Pleasant, London, in 1829, deserve notice on account of their origi-nd simplicity. In his specification is described a printing machine, or aving two tables with a form on each, the one to press the first side of t, and the other to perfect it, or print the second side. These two e placed on a vibrating frame, which is actuated by a crank, and brings ternately under a pendent-platten, which is brought down upon them the instrumentality of a crank, to give the impression. The frame upports the form-tables consists of a parallelogram jointed at the angles, refore the horizontal position of the forms is preserved, both when they ated to the platten to receive the impression, and depressed to the o receive a supply of ink. There is an inking apparatus for each laced at opposite ends of the machine: it consists of a long trough, and and supply-roller, of the usual description; with distributing-rollers, averse the forms, and are kept in their places by guides, with long ver-ts to receive their axes. When either of the forms is depressed, its ing-rollers are carried to the ink-trough to receive ink from the oller, which they transfer to the form by passing over its surface as it is d.

aper to be printed is supplied to the machine from a feeding-board, the medium of an endless web, passing over rollers, connected by bands to the main shaft, which communicates, simultaneously, to all parts of hine. The sheets of paper being placed on the feeding-board, a boy hem forward singly, when they are successively caught by the rollers web, by being pressed down upon them through the medium of a g lever, operated upon at stated times by the motion of the machinery. e sheet of paper is brought between the form and the platten, its well as the motion of the form, is stopped while the impression is cated to it. This stoppage of motion is effected without interfering motion of the main shaft, and other parts of the machinery, by the teeth from a portion of the circumference of the spur-wheel, which cates motion to the web-rollers. After the first impression has been e sheet, it is carried about another roller, which turns its reverse side e platten, while the second or perfecting form is brought, by a vibra-e frame-work, under the paper to print the second side, or to give it

the perfecting impression, which is effected while the motion of the web-roller is stopped as before.

The platten is suspended over the centre of the press, and guided perpendicularly down by strong frame-work, and the pressure is produced by a vertical rod, connected with the platten at its upper end, and with a revolving crank at its lower end; a lever with a counterpoise is also connected with the lower end of the vertical rod, which compensates for the weight of the rod and platten, while the two form-tables balance each other on the vibrating frame; and thus jarring irregularities in the motion of the machinery is prevented.

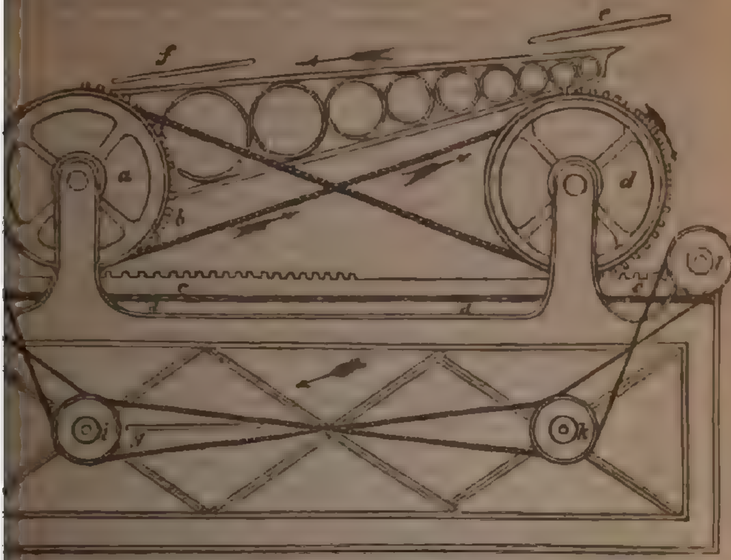
The second improvement consists of a printing press, or machine, with but one form-table, which is placed upon a frame, and made to vibrate between two plattens, placed in oblique positions, where impressions are given by each with such rapidity, that two or more feeding-boards, with the requisite web-rollers, are required to supply it with paper. This is a single printing machine, and there the sheet has to pass through it twice before the printing is completed. It differs, however, materially from the common printing machines; it having two plattens, and a form-table placed between them on a vibrating frame, instead of running forwards and backwards on wheels, as is the case with the printing machines employed at the *Times'* office, and other machines made by Applegath and Cowper.

Mr. Wayte's third improvement consists in a new arrangement of inking rollers, by which he is enabled to diminish their number, and to effect a saving in the ink, by conducting the supply to such places only of the distributing rollers as come in contact with the types: this is effected by causing the inking rollers to pass over distributing blocks, which are made to correspond with the types in the form, and supplied with ink by a transferring roller; by this means the ink is supplied only to such parts of the rollers as come in contact with the types. This inking apparatus is equally applicable to the printing machines invented by Mr. Wayte, and to those of the usual construction.

Mr. David Napier, of Fitzroy Square, London, a manufacturer of printing machinery, of great ability and experience, specified a patent in 1831, granted to him for "certain improvements in printing and pressing machinery, with a method of economizing power, which is also applicable to other purposes." There are four inventions contained in this patent, all having reference to the printing business, and calculated to increase its facilities; we therefore subjoin a brief account of them.

The *first* is a printing machine, of the kind called a perfecting, or that which prints both sides of the sheet before it is delivered from the machine. There are two forms of type placed on the same traversing stage, so far apart that the distance between them shall be equal to the length of one of the forms. The sheet of paper to be printed is conveyed to the forms by endless felts and guide rollers, in the manner usually adopted in the printing machines manufactured by Cowper and others. On the axes of the two rollers, which give the pressure to the paper while on the type form, are fixed two wheels, with teeth extending only half round, each of which takes into racks fixed on the side of the form stage. The diameter of these wheels is equal, and they are made exactly to correspond with the diameter of the rollers with which they move; they are connected together, and made to turn in different directions by means of a band passing over equal pulleys on each, and being so adjusted with respect to each other, that the teethed half of the one shall be upwards while the teethed part of the other is downwards; and thus they will take into their respective racks, and cause the form to traverse backwards and forwards alternately. This arrangement will be better understood by inspecting the opposite diagram. *a a* represents the two cylinders which give the impression, with spur-wheel teeth on half the circumferences, as shown at *b b*. These teeth take into the racks *c c*, which being connected with the form stage *d d*, communicating to it a reciprocating motion. The sheets of paper to be printed are receiving alternately from the feeding-tables at *e f*, and receive the first impression as they pass under the cylinder *a*; whence following the course pointed out by the arrows, they pass around and receive the second, or completing impression, in returning

the cylinder *a*, and are finally delivered on the receiving board *g*. The felts, tapes, and guide rollers, by which the sheets of paper are con-, are not shown in the drawing, as they do not differ materially from those ly adopted for this purpose. *h i k* and *l* represent a series of pulleys, by the inking apparatus is put into operation.



Napier's *second* improvement applies to the inking part of the printing nea. It consists of a series of rods, jointed and connected together in anner of the system of rods which constitute the parallel motion of a engine; and these are applied to produce an alternating rectilinear to a frame carrying a set of inking rollers. This inking apparatus is ded from a frame extending over the type forms; and it is equally ble to printing machines on a large or small scale, whether actuated by or any other first mover.

third improvement consists of a pair of pressure rollers for the purpose sing the sheets of paper after they have been printed, instead of using an lic or screw-press, to give to printed paper the required degree of smooth- The construction of Mr. Napier's rolling-press does not materially differ from ling-press applied to bookbinding a few years ago by Mr. William Burn, by-street, and which has now nearly superseded (in London at least) the ous and uncertain processes of beating, formerly practised by bookbinders. ollers of the press patented by Mr. Napier are placed horizontally, with to each other, while those of the press introduced by Mr. Burn occupy ical position.

fourth invention described in this specification consists of a plan for ing the intermittent power of an alternating action, when applied to e continuous rotatory motion. The power is to be applied by a lever to a pump-handle, which turns freely on a fixed axis or fulcrum; at one ty near this axis is a click or pall, which takes into the teeth of a ratchet wheel attached to the axis of a box containing a coiled spring, ne end fixed to the axis, and the other to the circumference of the con- box: to this box is fixed a toothed wheel, which takes into the teeth of n, or on the axis or shaft, to be put into rotatory motion; and thus the ing action of the lever, which is only employed in winding up the

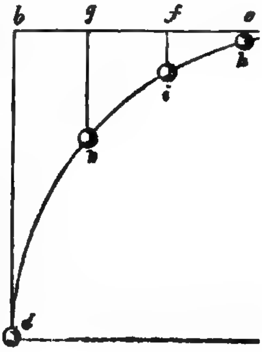
spring, is rendered efficacious in giving continuous rotatory motion to or spur-wheel, and hence to any system of machinery to which it applied.

A patent "for improvements in printing machines" was granted to B of Shoe Lane, London, in 1831, which appear to us to be of impo they effect a considerable diminution of the quality of alternating m which economy of power, and a saving of repairs are likely to result. form is made to rest stationary, while the inking-rollers are made to forwards and backwards over it, receiving their supply from a ductor r then passing over a distributing table, on which they have an end as rotatory motion, that the ink may not accumulate upon them in rid they deliver the ink upon the types both in passing forwards and ba The frisket is attached to a slight traversing frame, which is furnishe series of tapes, on which the paper is laid, so that the tapes may com tact only with the spaces between the pages. This frisket frame mo an iron railway, and having received a sheet of paper to be printed, it till it comes over the types and under the platten, being preserved distance from the types by spring supports; it is liberated by pi jecting from the platten, and yields to the pressure of the platten whe down to give the impression. The frisket frame is furnished with conic pins, with small apertures in their tops for the reception of other ste for regulating the register when the sheet of paper is reversed for co The motions of the various parts of this machine are produced in the which they are required through the medium of various levers, wheels, c pulleys, possessing separately little novelty, but well arranged to effec bination the different and somewhat complicated motions of the these, however, we have not deemed necessary to detail at length, as forms of them may be used without abandoning the principle of the i

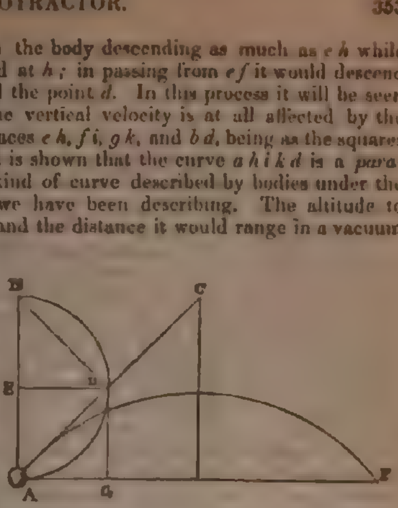
PRISM, in Geometry, is a solid body, whose two ends are equal and parallel planes; and its sides connecting those ends are parallelog

PRISM, in Optics, is a triangular prism of glass, which separates th light passing through it in consequence of the different degrees of refr that take place in different parts of the same ray.

PROJECTILES. The laws of projectiles, or bodies projected by an sive force into the atmosphere, are identical with those by which th of bodies falling perpendicularly in free space are governed; so that w relation is understood, a knowledge of the one necessarily leads to an ance with the other. It is well known that if a body be under the inf a single impulsive force, as a blow with a hammer, or the explosiv gunpowder, its velocity will be uniform; that is, it will pass over eq in equal portions of time. It is also well known that a body falling space falls with an accelerated velocity, so that the spaces fallen th successive equal portions of time, continually increase. Now, if we apply these facts to the case of a body projected through the air, we shall find the same laws to be preserved throughout. In the diagram, on the following page, if we suppose a body *a* projected horizontally, that is, in the direction *a b*, it would, if not acted upon by the force of gravity, proceed to describe the equal spaces *a e*, *e f*, *f g*, and *g b*, in equal successive intervals of time. On the other hand, if we suppose the body simply to fall by its own weight, it will fall through spaces equal to *e h*, *f i*, *g k*, and *b d*, in exactly the same space of time which it would take to pass over the former spaces. Let us now suppose the two



o be simultaneous, then the body descending as much as *e h* while om *a* to *e*, would be found at *h*; in passing from *e f* it would descend , and so on till it reached the point *d*. In this process it will be seen ther the horizontal nor the vertical velocity is at all affected by the f the other. From the spaces *e h*, *f i*, *g k*, and *b d*, being as the squares stances *a e*, *a f*, *a g*, *a b* it is shown that the curve *a h i k d* is a *para*-ich, in all cases, is the kind of curve described by bodies under the of two forces, such as we have been describing. The altitude to y projectile would ascend, and the distance it would range in a vacuum ascertained. Let A B ght through which the would ascend by the pressed upon it at its d A C the direction in s projected. Describe rcle B D A upon the and where the direction he circumference, draw E D perpendicular to will E D be one-fourth zontal range, and E A de to which it will



If the horizontal range and the projectile velocity be given, the so as to hit a given object, may be thus found. Take A G equal to of A F, and draw G D perpendicularly to meet the circle, then will e direction in which the projectile must be cast to strike an object at e range A F and the direction A C are known, then the velocity that ven is found by taking A G, equal to one-fourth of A F, raising the ular G D, and drawing A B perpendicular to A F, till it meets D B, pendicular to A C; then will A B be the altitude due to the projectile Since there may be two perpendiculars on the semicircle of equal re will be two different elevations that will produce the same range; the radius is the longest line that can be drawn in this way, the nge will be when the angle of elevation of the projecting machine is f a right angle, and in this case it will be just double the altitude due ial velocity. The time which the body would occupy in its flight is qual to the time a body would take in falling through four times the the parabola which it describes.

foregoing remarks apply only to the motion of bodies in a vacuum, therefore require great correction before they are applied in practice, particular cases. When used to regulate the discharge of large ther bodies whose initial velocities do not exceed three or four hun-they may be considered as tolerably accurate. But in cases of great velocities, the theory is quite inadequate without several data drawn good experiments; for so great is the effect of the resistance of the ctiles of considerable velocity, that some, which, in the air, range en two and three miles at the most, would, in vacuo, range about ten r, or between twenty and thirty miles.

XIDE. A term used in chemistry to denote the minimum of .

ACTOR. An instrument used for protracting, or laying down on ngles of any figure. The protactor is commonly a small semicircle of y divided it into 180 degrees; the ends of the arch are connected by rule, the outside edge of which is the diameter of the circle. It nly to draw angles on a plane, but likewise to examine those laid r this purpose, there is a small point in the centre or middle of the straight rule, which point, being placed upon the vertex of the angle e of the rule, so as to coincide with one of the sides of the angle, e of the angle then cuts through the number of degrees marked on

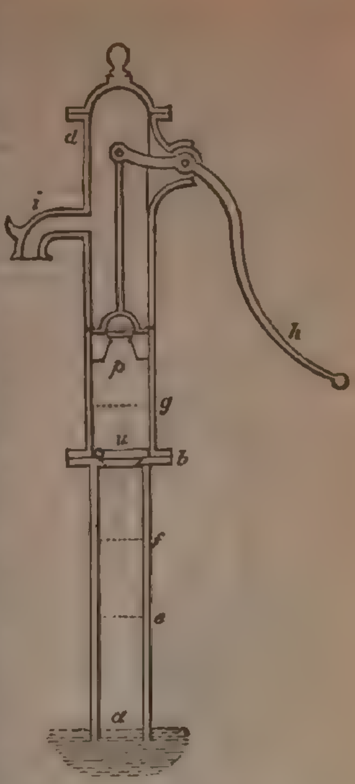
the protractor, which is its true measurement. Protractors are now usually made in the form of a parallelogram, and graduated with diverging lines from a central point upon one edge, to the opposite edge where the degrees are marked.

Mr. Twitchell's improved protractor is stated in the *Franklin Journal* to consist of a circle, marked with the lines of sines, tangents, secants, semi-tangents and chords. To the centre of the circle is annexed a scale of the shape of half a cross, agreeing with the line of chords on the circle, and marked on each limb with the line of equal parts. The cross limb of this scale consists of two parts; to one of which is annexed a semicircle, marked with the line of chords, the other part turning on its centre, and agreeing with the line of chords on the semicircle, serving both as a protractor and scale. To the centre of the whole circle is annexed a small limb, agreeing with the line of chords on the circle, and extending over the scale, and serving as a secant to the circle. This scale exhibits the use of chords, sines, secants, and tangents, and the mode of applying them to angles, giving the sides and chords of any triangle, and also the sine, tangent, and secant; likewise latitude, departure, course, and distance. For drafting, this scale is particularly useful; for in plotting, nothing more is required, than to turn the scale to the course, and mark the distance. The correctness of the description thus given of the instrument by Mr. Twitchell is corroborated by the valuable testimony of the learned editor of the Journal, Dr. Jones, who remarks in a note, that the instrument, "in addition to the purposes indicated," will be found "particularly useful in teaching trigonometry, as it renders the relationship of the angles objects of sense."

PUMICE-STONE. A light grey-coloured substance, of a fibrous spongy texture, supposed to be formed from felspar, in volcanic fires, and thence ejected in a state of fusion.

PUMPS. Machines for raising water and other fluids; usually consisting of a tube or tubes, in which valves and pistons, or buckets, are made to operate, to produce the effect. Engines differently constructed, and particularly those upon a larger scale than ordinary pumps, are generally termed HYDRAULIC MACHINES, which we have already treated of under that head. The ordinary definition of a pump is, "a machine in which water is raised by the pressure of the atmosphere," which accords with the prevalent but erroneous notion, that the atmosphere does of itself raise water to a height of thirty feet; notwithstanding it is known to those who have considered the subject, that it does not, in fact, contribute in the slightest degree to raise it at all; and that the same force is requisite to raise a pound of water a given height, as to raise a pound of lead, or of any other substance, through the same space. Of the evident truth of this fact, the reader, if a novice, will be satisfied upon reading our article on hydraulics or hydrodynamics, and by attending to the following description of a

Common, or "suction" pump.—This pump consists of two hollow cylinders, a b and b d, placed one under the other, and communicating by a valve u, which opens upwards. The cylinder a b is called the suction pipe, and has its lower end immersed in the well, or reservoir, from which the water is to be raised. In the barrel b d a bucket or piston p is moved, having a valve in it which opens upwards; this piston should move air-tight in the cylinder. At i is a spout for the discharge of the water. Supposing the bucket to be at the bottom of the cylinder b d, and in close contact with the valve u; upon elevating it, the piston-rod is kept closed by the atmospheric pressure, and if the valve were not permitted to rise, a vacuum would be caused between it and the piston, the elevation of which would then require a force equal to about 15 lbs. multiplied by as many square inches as are in the section of the piston. But the moment the piston begins to ascend, the elasticity of the air in the suction-pipe beneath opens the valve u, and the air rushing through, balances part of the pressure on the piston. Now, if the water at a were not permitted to rise, the air between the piston and the surface a would be rarefied by the ascent of the piston. It would, therefore, press against the lower surface of the water with a force less than the atmosphere; but



of the atmosphere presses ...e of the water in the well; ...iminished elasticity of the ...ction-pipe not being a coun- ...this, the water is necessarily ...into that pipe. The height ...e water will rise in the suc- ...will be proportioned to the ...e stroke of the piston p; ...uppose it to have risen to ... the dotted line e, there is ...pound column of air and ...ng on the level a; namely, ...of water $a\,e$ and the elastic ...air in $e\,b$. These two toge- ...e the atmospheric pressure ...ernal surface of the water ... It consequently follows, ...e in $b\,e$ must be rarefied, ...lasticity falls short of the ... pressure by the pressure of ...of water $a\,e$. As a column ...ut thirty-three feet in height ...e atmosphere, it follows that ...y of the air in $b\,e$ is equal to ... of a column of water whose ...qual to the excess of thirty- ...bove $b\,e$.

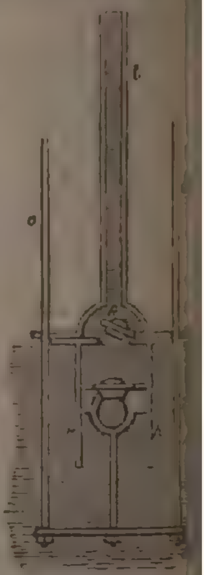
...next stroke of the piston, ...quantity of air is extracted, ...diminished elasticity under ...causes the water to ascend ...el f, and the succeeding ...e it to the levels b and ...to, this machine has only ...f an air pump, but at the ...t of the piston, the water ... through the piston-valve, which closes and prevents its return; ...the next ascent of the piston, the pressure of the atmosphere ...e water through the valve u. The succeeding descents and ascents ...d with like effects, until the water has reached to a level with the ...here it is discharged at every succeeding stroke afterwards. The ...sary to lift the piston is the weight of a column of water, whose ...at of the level of the water in the well, and whose base is equal to ... of the piston. This force, therefore, from the commencement of the ...tinually increases, until the level of the water rises to the discharging ... thenceforward remains uniform.

...mmon, or sucking pump, operates by the production of a vacuum ...working-barrel, by which the external atmospheric pressure is called ..., and forces the water of the well up the suction-pipe, it follows, ...ton, at its greatest elevation, should never exceed the height of ...feet from the surface of the water in the well.

...anding the common lifting pump, is incapable of raising water from ...thirty-three feet (in practice but thirty feet) below the place where it ...d, yet it may be made to deliver water at almost any required height ...ton, by the application of a continued straight pipe into the top of the ...rel $a\,b$ of the preceding figure. Thus, if we suppose twenty or thirty ...f pipe to be so added to it, since the water once raised cannot ...wards again through the piston valve, it must continue to rise with ...of the pump, until at length it will flow over the top of the pipe, or

through a spout inserted in any part of its side. In this case atmo[spheric] pressure has nothing to do with the elevation of the piston, consequently [it may] be carried to any height that the strength of the pump, or the force em[ployed] is capable of; but the handle h, or any other contrivance by which the p[iston is] worked, must be fixed at the top of the additional pipe, and the pis[ton-rod] equally extended, in order that the working-barrel may be kept with[in the] limits of atmospheric pressure, which makes a pump thus arranged i[nappli]cable to very great depths, on account of the bending of the piston-rod. [If] cast-iron pipes are used, this may in a great measure be prevented, by [p]small pieces, with projecting arms of sufficient length to touch the inside [of the] pipe at each joint of the piston-rod, or about ten or twelve feet asunder; [and] this pump may be used for considerable depths with advantage. In [all] pumps to draw muddy or sandy water, it is always advisable to set the [foot] of the pump in a close wicker basket, or other strainer, because sand and stones very soon destroy the leather and working parts of any pump; when pumps are used for hot liquors, which is the case in many manufa[ctures], thick hempen canvas must be substituted for leather, unless the valves and [pis]tons are made entirely of metal, which is of course preferable.

The *forcing pump* is generally employed in mines or in situations whe[re it is] required to draw water from great depths. Pumps of this kind act b[y com]pression instead of exhaustion. Although atmospheric pressure is not necessary to the construction of forcing pumps, yet it is in most cases resorted to for raising the water, in the first instance, into the body of the pump where the forcing action commences and takes place; and when so constructed, such pumps are usually called *lift and force pumps*; and in all the machines of this description, the water may be raised to any required height, without any limit, consistent with the strength of the parts and the power at command. Forcing pumps do not differ materially in construction from the common pump already described; indeed, that pump, by a mere inversion of its parts, may be made into a forcing pump; that is to say, placing the piston below, and the stop-valve and delivering-pipe above, as shown in the subjoined figure, where $h\,h$ shows the inverted working-barrel, and i the inverted piston and rod, with a valve opening upwards; k is the stop-valve placed at the top, instead of the bottom, and also opening upwards into the rising pipe $l\,l$, which may be continued to any required height; the lower end of the working-barrel is quite open, and must stand in, and be covered with the water it has to raise, so that no suction or feed-pipe is necessary to this pump; and the piston i may be worked by a frame $o\,o$, or in any other convenient m[anner].



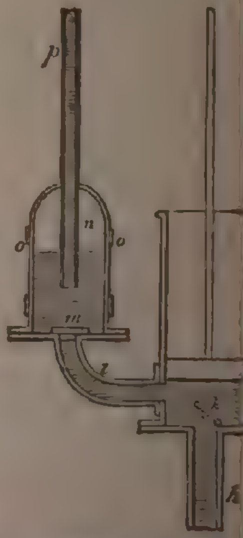
After the description already given of the common lift pump it will be [un]necessary to say anything of the action of this machine, as it is presumed the fig[ure will] render it sufficiently obvious. While the lower end of the working bar[rel is] immersed in water, and the piston i moves upwards and downwards, the [barrel] will be filled through the piston-valve at each down-stroke, and at e[ach up-]stroke its contents will be expelled through the stop-valve k, into the as[cending] pipe $l\,l$; and whatever the diameter of this pipe may be, still its resista[nce will] constantly be equal to the weight of a column of water of the size of the [work]ing-barrel, and of a height equal to the perpendicular altitude of the w[ater in] the ascending pipe; for this pipe may be placed horizontally or obliquely [so as] materially to alter its length; but it is the perpendicular height betwe[en the] surface of the water to be raised, and its point of discharge, which mus[t]

o account in estimating the load upon a pump; since increase of out height in the pipe produces no other resistance than that of fric- is easily overcome by increasing the capacity of the pipe. It may the preceding pump is applicable to every purpose and to every situa- raising water from mines and the deepest places; but this is not ing to the almost imperceptibly small elasticity of water, and the e vis *inertia*, which belongs to fluids in common with solid matter. the pump shown in the last figure, if we presume the pipe *l l* to be , that water has not sufficient elasticity to permit the barrel *h h* to contents through the valve *k*, without putting all the water contained otion, while, when the piston at motion will be at an end. *l l* will therefore be in an alter- rest and motion; and if the ng, and its quantity great, the ill be very considerable; that will require a considerable exer- to get it from a state of rest and when it has once begun ill have no immediate tendency in to rest, but might be con- motion with less force than as originally employed to move cent of the piston, however, ent time for all the motion that icated to be completely lost; in working this pump, we not e weight of the column to over- e natural inertia to combat with oke. This may, in a great removed, by keeping two, or better, three pumps constantly triple or three-throw crank; gly this expedient is generally all small engines for throwing eat height, for by this means never permitted to stand still but a constant flow or stream d. No illustration is necessary the reader the combination of worked by a triple crank, giving the alternating motion of the series, at equal dis- e and space throughout the ut a mechanical arrangement, triple crank is employed to ump, containing three buckets in the same working barrel, ng the same effect as three

s to require the aid of graphic delineation; accordingly, we annex ch the process of raising water is thus conducted; it is the inven- Downton, of Blackwall, and was the subject of a patent granted to 5. The figure in the margin may be called a front elevation, the working barrel or cylinder being broken away to show the *a* is the uppermost bucket or piston, the rod of which *b b* is hol- g connected to a bent arm *d*, it is thereby attached to one of the evolving three-throw crank *e*. The middle bucket *f* has also a *g*, which, being of smaller dimensions than the former, slides freely d is connected to the crank *e* by another bent arm *h*. The lower- has a solid rod *k k* which passes entirely through the hollow rods

of the other buckets, and is attached directly to the middle of t
Upon each of the limbs of the crank are placed anti-friction wheels
in elliptical slots at the upper end of each rod, by which the attriti
rubbing surfaces is considerably reduced.

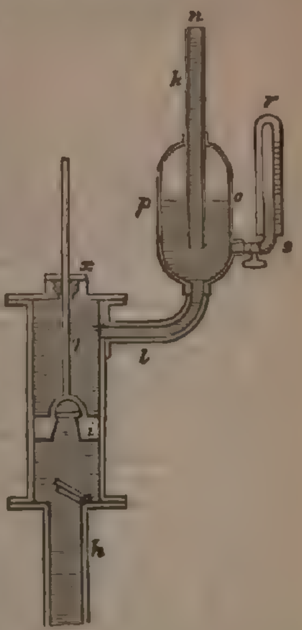
By this arrangement it will be seen that, on turning the crank by th
the buckets alternately receive and lift the water which has passed
through their valves. On raising the bucket *i* a vacuum is effected un
and the water rises from the main pipe *l*, and fills the lower part of th
der; on the descent of *i*, the water is received above it through its valv
i descends, *f* rises, so that the water fills the space between the two
re-action of the bucket *i*, more water is received into the barrel from th
while the upper bucket *a* operates upon the middle one *f* in the same
as *f* has been described to operate upon *i*; thus, by the simultaneous al
motion of the three buckets or pistons, the water is discharged in on
uous stream. Although this invention reflects credit upon the ingenui
inventor, we must be permitted to question its superiority over simpler
It will be evident that the patentee's object, (and, if we recollect rig
stated so in his specification,) is to obviate the employment of an
But in doing this he has constructed a machine quite as expensive,
incurred a greater waste of power, owing to the friction that must take
his concentric tubular piston-rods; besides a greater liability to derang
the multiplicity of parts.



The forcing pump is made in two forms, suited to the situation and circumstances under which it has to work. The simplest construction is shown in the annexed cut. It consists of a truly-bored cylindrical working-barrel *f*, the top of which is quite open to admit the solid piston, which works it in a perfectly air and water-tight state, by means of the lever or handle, or any other more convenient application of power; *h* is the feeding-pipe, dipping into the water to be raised, as in any other pump, and this pipe may, of course, be made of any length under thirty-three feet; *k* is the stop-valve covering the top of the feed-pipe, and permitting water to rise into the working-barrel as the piston ascends, but not permitting it to return again; so that whenever the piston is raised by its handle, the barrel will be filled with water forced up the pipe *h* by atmospheric pressure; and when the piston descends again, since there is no valve in it to permit the water to pass through it, it will be
forced up the lateral pipe *l* (opening into the bottom of the working
and through the valve *m*, which prevents its returning back again, so t
constrained to find its way up the rising pipe *p*, fixed above the valve
this pipe may be continued to any required height, without regard to th
sure of the atmosphere, since the ascent of the water does not depend
action, but upon the mechanical force that is applied to the handle to
the piston. While the piston rises to fill the working-barrel, the valv
be shut, and of course all motion of the fluid in the pipe *p* will ce
hence the use of the air-vessel *n*; for it will be seen that the pipe
joined on immediately above the valve *m*, but that it passes through th
an air-tight copper, or other hollow vessel *n*, and proceeds nearly to th
of it. Air being a lighter fluid than water, will of course occupy the u

of this vessel; and as soon as the action of the pump has filled it with water up to the line *o o*, or just above the lower end of the open pipe *p*, all air that is above the water will be confined, and unable to escape. If, now, the working of the piston be supposed to throw water more rapidly into the air-vessel than it can escape by the pipe *p*, it is evident that such confined air will be condensed into less compass than it naturally occupies, in order to make room for the water; and as the elasticity of air is constant, and increases in power with its degree of condensation without limitation, so the spring of the air in the air-vessel will become a counterpoise or equivalent for any height to which the pipe *p* may be carried; and although the water in the pump explained at page 357, would not admit of condensation so as to permit a fresh quantity of water to enter the ascending-pipe without putting all its contents into motion, yet the introduction of the air-vessel obviates this difficulty; for now the new quantity of water is not delivered into a former quantity of inelastic water, but into a vessel filled with air, which readily allows a change of dimensions; and while the piston is rising, and projecting no water, the previously condensed air in *n* has time to re-expand into its former volume, by expelling an equivalent quantity of water up the pipe *p p*; and thus, if the air-vessel is large enough, a constant and equable current may be maintained.

The annexed figure shows another form of the forcing pump, though this construction is generally called the lift and force pump; its formation is the same as the last-described figure, except that the piston is not solid, but is perforated, and covered by a valve opening upwards, as in the common lifting-pump; the piston-rod *q* likewise moves in an air-tight manner through a stuffing-box, or collar of leather, on the top of the working-barrel, which, in this case, is closed; and the lateral delivering-pipe, with its air-vessel, proceeds from the upper instead of the lower part of the working-barrel. This pump not only has the stuffing-box, but three valves, instead of two, as in the last example: it is, consequently, rather more intricate and expensive in its construction, with no other advantage than that it is rather more cleanly in its working; for if the piston of the former pump is not quite water-tight, a quantity of water may flow over the open top of its working-barrel, which cannot be the case in this pump, if well made. Their action is very nearly alike, for this last pump raises water through the suction-pipe *h*, by the elevation of the piston *i*; on depressing the piston, that water passes through it by its valve, and



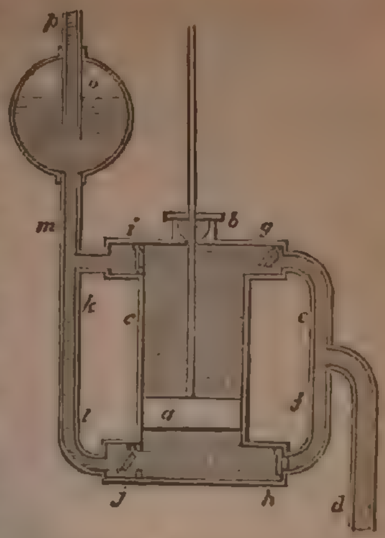
gets above it to fill the upper part of the working-barrel; on the re-ascent of the piston, the water, being unable to escape at the top of the barrel on account of the cover and stuffing-box *x*, is forced up the lateral pipe *l* into the air-vessel, and from thence passes away by the ascending-pipe *k* as before. When the water has risen in the air-vessel to the dotted line *p o*, so as to cover the lower end of this pipe, the air will be confined, and their operations must be alike. The air-vessel must be suited in its capacity to the magnitude of the pump or pumps that deliver water into it (for several pumps are frequently made to open into one common air-vessel), and ought, in all cases, to contain at least six or eight

volumes of the pump, in order that the increasing expansive force of the air may not influence the motion of the piston during a single stroke; but for this no precise rule can be given, as the relative dimensions may vary to suit the circumstances of the case. These forcing pumps with air-vessels are now very generally adopted in water-works for supplying cities or towns; and the height at which the water is at any time delivering, may be very nearly estimated if the air-vessel is large, and the supply equable, by examining the degree of condensation of the air within it. This is very conveniently done by a gauge, consisting of a glass tube with a closed top, applied by a stop-cock to the lower part of the air-vessel, or that which is always filled with water; at *r s* such a gauge is represented; and as it has an open communication with the air-vessel when the cock *s* is open, the air in the top of the tube will suffer the same condensation as that within the vessel. The height of the spaces occupied by air within the tube must be measured; and as the air at its ordinary density will balance a column of water thirty-three feet, high, so if confined air is loaded with the weight of such a column, it will shrink, or be condensed into half its former bulk; whenever, therefore, the air contained in the tube *r* is diminished to half its original length, the condensation within the air-vessel must be equal to two atmospheres: or, what is the same thing, the water in the pipe *p* must stand at the elevation of 33 feet. If the water in *p* is raised to twice 33 feet, or 66 feet, then the condensation within the air-vessel must be equal to three atmospheres; and the air within it, as well as within the tube, will be diminished to one-third of its original bulk; one-fourth of the bulk will indicate four atmospheres of condensation, and be equal to the elevation of the water column to 132 feet, and so on, more or less, as the barometer may vary.

That useful machine, the fire-engine, or engine for extinguishing fires, is nothing more than two forcing-pumps, of the construction shown at page 358, working into one common air-vessel placed between them, and from which the spouting-pipe for directing the water upon the fire proceeds. The handles are so disposed, that while the piston of one pump is up, the other is down; and they are elongated for the purpose of enabling a great number of men to work them at the same time, for the purpose of throwing a very large quantity of water, which is rendered a continuous stream by the action of the air-vessel. See FIRE-ENGINE.

It is curious that the most ancient pump we are acquainted with, namely, that of Ctesibius, at least, as it is handed down to us, very closely resembles the present fire-engine, for it consists of two forcing-pumps, disposed as just described; but instead of discharging their contents into an air-vessel, they merely deliver them into an intermediate close cistern, from which the water ascends by a perpendicular pipe, and in which nothing is wanting but the condensation of air. It must, however, be observed, that both the pumps last described would be forcing pumps, without their respective air-vessels; and though they act much more advantageously with, they are sometimes constructed without those appendages.

We now proceed to describe a pump with a double action, producing the same effect in its up as in its down-stroke; the water being alternately raised and forced on the opposite sides of the piston; that is to say, by the up-stroke of the piston, the water above it is forced out of it into an air-vessel, and, at the same time, the cylinder is re-charged by the water following the piston underneath; then by the return or down-stroke, the water underneath is forced out, and it flows in above, ready for the repetition of the operation, and so on continuously. In the diagram on the following page, *a* represents a solid piston, its rod working air-tight in a stuffing-box *b*, fixed at the top of the pump-barrel *c c*. The water from the well, supposed to be not more than thirty feet deep, ascends into the vacuum of the pump by the pipe *d*, and is conducted by a branched pipe *e f* to the top and bottom of the barrel alternately, through valves *g* and *h*, which open inwards. On the opposite side of the working barrel are two corresponding apertures, furnished with valves *i* and *j*, opening outwards, and conducting the water by a branch-pipe *k l* into a single tube *n*, leading into an air-vessel *o*, whence it is discharged by the tube *p*. In the

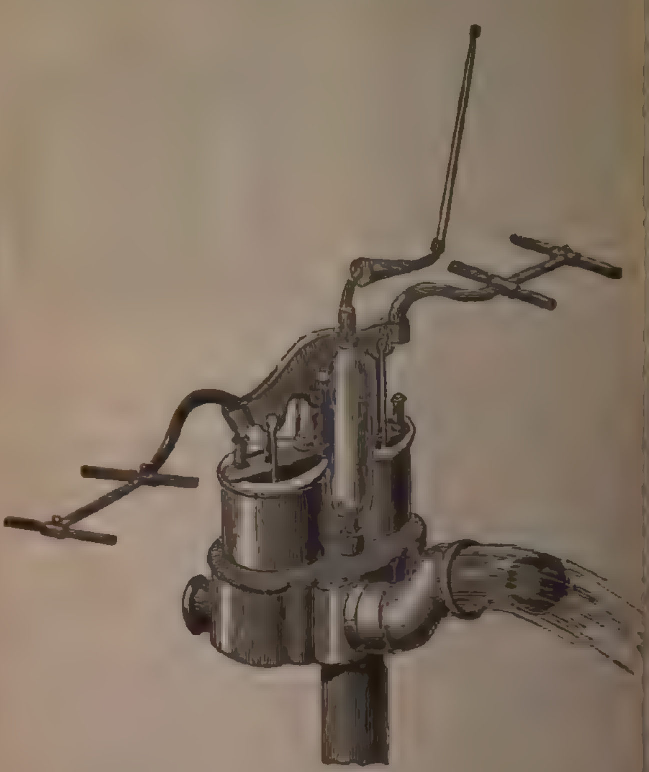


piston is shown as having ...ched the bottom of the ...y the force thus exerted ...he valve h, and impelled ...hrough the valve j, the ...nd pipe m, into the air- ...here the elasticity of the ...g upon the surface of the ...forced it up the pipe p. ...operation there has been ...y to the production of a ...ove the piston; conse- ...e pressure of the air, ...n the surface of the water ..., has compelled it to ...piston in its descent, and ...chamber above; after- ...n the ascent of the piston, ...l force shuts the valve g, ... the valve i, through ...water is propelled along ... k, pipe m, air-vessel o, ...the pipe p. During this ...stroke, the water from ...ssing along d and f, has ... valve h, shut the valve ...lled the barrel under the piston; and thus the process is continued as ...pump is worked.

...ge Vaughan, of Mile-end Old Town, took out a patent in 1830 for ...ting pump, acting in a horizontal direction; the principle of its ...may be readily understood after the description of the foregoing, and ...ng it to a high-pressure steam engine, with such difference only as ...better to the pumping of water. The working chamber is either ...or square; but each end of it is considerably enlarged downward, ...valves that receive the water from the rising main are situated. The ...id and packed like those for steam; the piston-rod passes through a ... at one end of the chamber, and is attached, at the farthest ...to a cross head, to which is connected two spear-rods. One of these ...on each side of the pump, and beyond the opposite end of it, to a ...h is made to revolve in plummer blocks (fixed to a suitable frame), ...ed either with a winch, by manual labour, or by any other suitable ...he motion thus described is, of course, nothing but the ordinary ...ion. In order that the piston may not, by its weight, wear most on ...le, the piston-rod is continued on both sides of it; and beyond the ...e piston, the rod is supported by an anti-friction wheel; thence the ... tubular case, closed at the furthest extremity to prevent the escape ...r, as it is not packed. The action of the pump is this: suppose, by ...ion of the crank, the piston to be moving to the right hand, a ...produced on the opposite side of the piston, which causes the valve ...ing main to be opened by the pressure of the atmosphere, and the ...thereby filled with water. On reversing the stroke of the piston, or ...left, the right-hand valve is opened from the rising main, and that ... chamber filled with water, while the water which previously ...e left end of the chamber is forced out by the piston through ...lve on the upper side; the succeeding stroke in like manner dis- ...water in the right chamber, and fills that of the left, and thus the ...ntinuous. In the drawing attached to the specification, a large ...ical wheel is shown as fixed to the upper side of the pump, for the ... the water delivered through the upper valves, and in the crown of ...a pipe for conducting the water, if required, to a greater elevation.

It would obviously have been better, had the patentee made the upper part of this vessel into an air-chamber, by causing the ascending-pipe last mentio[illegible] to dip nearly to the bottom of it.

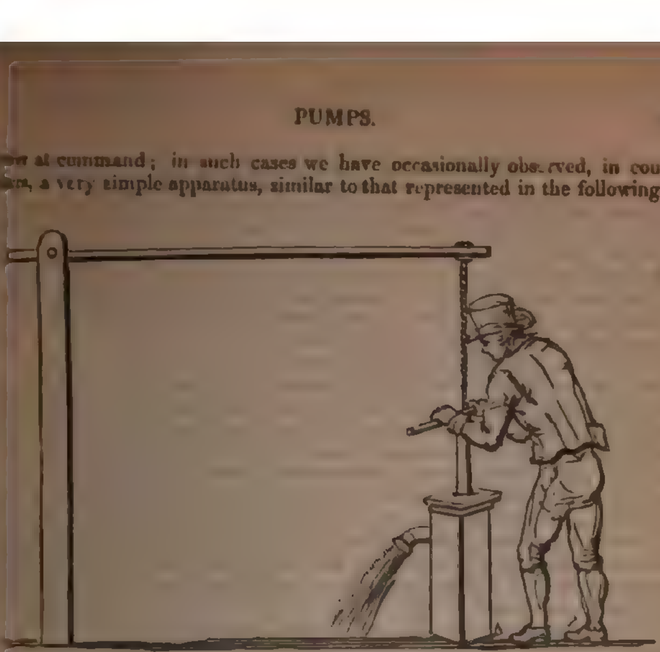
The annexed engraving is a representation of a pump constructed by [illegible] Clymer, on the plan of the ingenious Benjamin Martin; but the suction p[illegible] and the valves are so disposed as to retain any heavy bodies that may be ra[illegible] by the pressure of the atmosphere acting upon the vacuum.



The above perspective sketch shows that the rising main leads into a sp[illegible] valve-box, in connexion with two short and wide working-barrels, left op[illegible] the atmosphere. The piston-rods are attached to a lever, vibrating on a c[illegible] fulcrum which is mounted upon a standard between the two cylinders; [illegible] this lever branching handles are united, to enable many hands to be emp[illegible] in working it. The large volume of water discharged from the barrels at [illegible] stroke of the pump causes a constant powerful stream up the rising ma[illegible] that any globular substances nearly fitting it, as cannon balls, have no o[illegible] unity to fall down by any intermission of pressure from underneath; they [illegible] quently get lodged in the valve-box, and are ejected by the down-stroke [illegible] ump. When employed as an engine to discharge water to a great heig[illegible] tance, an air vessel is screwed on, as represented, and the nozzle i[illegible] plugged or capped, by which the current is directed through the air vessel.

In drawing water from great depths, the weight of the pump-rods an[illegible] water together are sometimes more than can be easily accomplished b[illegible]

...er at command; in such cases we have occasionally observed, in country ...rn, a very simple apparatus, similar to that represented in the following cut,



...ployed to counterbalance the weight of the rods. In this case, the pump- ...and handle is suspended to a wooden spring, of sufficient elasticity to ...ain the weight of the rods, and to require a part of the man's force to ...ress the piston or bucket, in return for which the spring assists him in the ...upwards. Some persons would be apt to imagine that power was thus ...ed; but a little consideration will enable them to perceive that it is only ...different distribution of the same force that the desired effect is produced.

...n Dr. Gregory's *Mechanics*, vol. ii. is the fol- ...ing description of a pump, with little friction, ...h may be constructed in a variety of ways ...ny common carpenter, without the assistance ...pump-maker or plumber, and which will be ...effective for raising a great quantity of water ...all heights, as in draining marshes, marl- ...quarries, &c., or even for the service of a ... It is exhibited in the subjoined diagram, ... *a b c d* is a square trunk of carpenter's ...k, open at both ends, and having a little ...n and spout at top. Near the bottom there ...partition made of board, perforated with a ..., and covered with a clack; *f f f f* repre- ...a long cylindrical bag, made of leather or of ...e canvass, with a fold of thin leather, such ...ep-skin, between the canvass bags. This ...ly nailed to the board *e*, with soft leather ...en; the upper end of this bag is fixed on a ...board, having also a hole and valve. This ...may be turned in the lathe with a groove ...ts edge, and the bag fastened to it by a ...ound tight round it. The fork of the piston- ...firmly fixed into this board; the bag ...distended by a number of wooden hoops, ...of strong wire *ff*, *ff*, *ff*, &c. put into it, ...e inches distance from each other. It will be proper to connect these ..., before putting them in, by three or four cords, from top to bottom, which ...eep them at their proper distances; thus will the bag have the form of a

barber's bellows or powder-puff. The distance between the hoops should be about twice the breadth of the rim of the wooden ring to which the upper valve and piston-rod are fixed. Now let this trunk be immersed in the water. It is evident, that if the bag be stretched from the compressed form which its own weight will give it by drawing up the piston-rod, its capacity will be enlarged, the top valve will be shut by its own weight; the air in the bag will be rarified, and the atmosphere will press the water into the bags. When the rod is thrust down again, this water will come out by the top valve and fill part of the trunk. A repetition of the operation will have a similar effect; the trunk will be filled, and the water will be discharged by the spout.

Many attempts have been made to introduce pumps worked by a continuous rotary motion, and a great deal of ingenuity has been exercised to prevent that waste of power arising from friction, with which they have all been more or less accompanied, but in a greater degree than the best reciprocating pumps. The reader who is solicitous for information on this point will find numerous descriptions of patented inventions of the kind in the *Repertory*, the *London Journal*, the *Register of Arts*, &c.; but as none of them have, in our opinion, been yet brought to work so well as the reciprocating pump, we shall here add only one of those contrivances, which possesses as strong claims to notice as any of them. It was the subject of a patent granted to Mr. Robert Winch, of Battersea, in 1826, and is delineated in the subjoined cut, which represents a vertical section. At *a a* is a cylindrical case of metal, the holes at the circumference being for the bolts, by which the circular side-plates are secured to it; *b* is the rising main pipe from the well; *k k k* the water-way, and *c* the discharge pipe; *d* is a circular box, turned round upon the hexagonal shaft in the centre by a winch outside. To the periphery of this circular box the flap-pistons *g g g g* are fixed by joints, and, as they revolve, they are successively closed as they come in contact with a "circular inclined plane" *e e*, the under side of which forms a stop to the upward course of the water on that side of the cylinder. On passing the curved piece *e*, the pistons successively fall open, with their edges touching the interior surface of the pump case; the water which has passed up from the main pipe through the valves *i i*, and occupied the spaces marked *k k*, is then carried forward by the pistons as they revolve, and is discharged in a continuous uniform stream at *c*. To prevent the pistons from striking violently against the cylinder, as they are turned against it by the resistance of the water, as

well as to avoid hard rubbing in those parts, catch-hooks *h h h h* are employed, the action of which is too obvious in the drawing to require more explanation.

to facilitate the shutting of the flap-pistons, as they come in contact with the curved piece *c*, each of them have a second joint in the middle, which gives them great flexibility of motion. In another modification of this invention, the patentee employs a rotary vane for closing the flap-pistons or valves in succession, instead of the curved stop described; but this arrangement renders it necessary to have a toothed wheel fixed to the axis of the circular box, to work a pinion on the axis of the rotary vane, that the motion of the latter may exactly correspond with that of the pistons. Since it is impossible, when a pump is well made and is in good order, that the piston can move without displacing the water that is above or below it, according to the circumstances of its construction, so, in all pumps that consist of cylindrical working-barrels and pistons, nothing more is necessary to ascertain the quantity of water they will deliver, than to calculate the solid or cubical contents of that part of the barrel in which the vacuum is produced, and to reduce it to some standard measure, and then to multiply this by the number of strokes made in a given time: thus, if a pump is nine inches diameter, and makes an effective stroke of about eighteen inches, such a cylinder will be found to contain 1134 cubic inches; and as 277¼ cubic inches make an imperial gallon, so four gallons will be equal to 1109 cubic inches; consequently, such a barrel will contain and throw out rather more than four gallons at every stroke; and supposing this pump to make ten strokes in a minute, it would yield above forty gallons in a minute, or sixty times that quantity in an hour, and so on. This rule applies in every case, whether the water is sent to a small or great elevation, because the piston cannot move without displacing the water in the barrel; but a small allowance must be made for leakage, or waste, because some water will constantly pass the piston and escape, or be otherwise lost and wasted.

PUNCH, AND PUNCHING. A punch is a short, stout piece of steel, or of iron steeled, used for stamping out pieces of metal, so as to make perforations in iron or other plates, for the insertion of rivets, screws, bolts, &c. In punching thick plates of metal, a powerful machine, consisting of a long and massive lever, worked by an engine, is generally used in considerable works; but as such machines are only in the possession of the comparatively few who require work of the kind to be well and expeditiously done, a simple and cheaply-constructed instrument for the purpose becomes an important appendage to the workshop; and such an instument we here present to the reader, which has

Fig. 1.

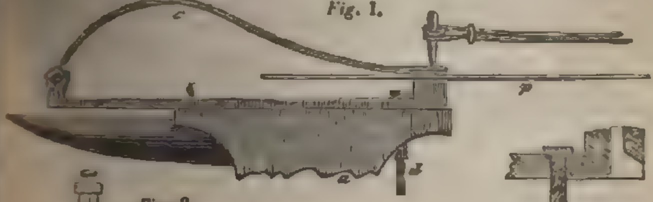


Fig. 2.

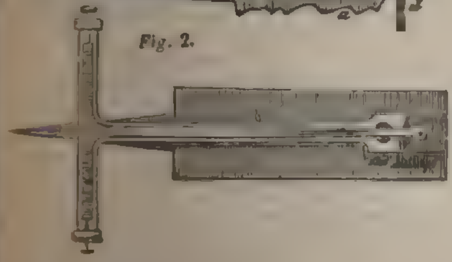


Fig. 3.

been long and advantageously employed by Mr. J. R. Hill, of the Westminster Road. *Fig.* 1 shows a side view of the machine, fastened on an anvil *a*, by a screw-bolt *b*. *Fig.* 2, a bird's-eye view of the same. *Fig.* 3, a section of the

punching-hole, showing a part cut out for the pieces to fall out; *p p* is a plate to be punched; the back end of the lower part of *b* is furnished with a T piece, each end of which is turned up and tapped for the reception of a centre screw. On these centre screws hangs the guide-arm *c*, which is also T shaped; the other end of this guide-arm has a hole *e*, just the size of the point of the punch to be used: in order to bring this hole to coincide with the lower one, it is only necessary to lengthen or shorten the arm, by bending it a little more or less, and turning the screws a little either way, which must be granted is much easier than adjusting a punch sliding in square holes, guides, &c. The set screws are also furnished with a nut each, to set them fast when adjusted. The reason for making it so long is, that any width of plate may come inside the holes. It is scarcely necessary to add, that a common rod-punch is used with its point only filed up to fit the hole.

PURLINES. Pieces of timber extending from one end of a roof to the other; they pass under the middle of the rafters, which they support, and counteract their tendency to sink in the middle.

PUTTY. A cement used by glaziers for fastening window-glass into the frames; it is used also by carpenters and other artizans for stopping holes in their work: it is made by kneading whiting and linseed oil together into a stiff paste; when dry it is very hard and durable.

PUTTY, Powder of. An oxide of tin, much used in polishing glass and other hard substances. When tin is melted in an open vessel, its surface soon becomes covered with a grey powder, which is the oxide of the metal. If the heat be continued, the grey assumes a yellow tint, which is then called putty.

PUZZOLANA. A kind of earth thrown out of volcanoes; it is of rough, dusty, granular texture. It easily melts *per se*; but its most important property consists in its forming a cement, when mixed with one-third of its weight of lime and water, which hardens very suddenly, and is more durable under water than any other cements.

PYRITES. Native compounds of metal with sulphur. The principal of this country are the sulphurets of iron, called martial pyrites, worked for the sake of the sulphur they contain; the sulphurets of copper are worked for both the copper and the sulphur they contain.

PYROLIGNEOUS ACID. See Acid Pyroligneous.

PYROMETER. A machine contrived to measure the expansion of metals and other bodies, occasioned by heat. Muschenbroeck was the original inventor of the pyrometer; the nature and construction of his instrument may be understood from the following account.—If we suppose a small bar of metal twelve or fifteen inches in length, made fast at one of its extremities, it is obvious that if it be dilated by heat it will become lengthened, and its other extremity will be pushed forwards. If this extremity then be fixed to the end of a lever, the other end of which is furnished with a pinion adapted to a wheel, and if this wheel move a second pinion, the latter a third, and so on, it will be evident that by multiplying wheels and pinions in this manner, the last will have a very sensible motion; so that the moveable extremity of the small bar cannot pass over the hundredth or thousandth part of a line, without a point of the circumference of the last wheel passing over several inches. If the circumference then have teeth fitted into a pinion, to which an index is attached, this index will make several revolutions, when the dilation of the bar amounts only to a quantity altogether insensible. The portions of this revolution may be measured on a dial plate, divided into equal parts; and by means of the ratios which the wheels bear to the pinions, the absolute quantity which a certain degree of heat may have expanded the small bar can be ascertained; and conversely, by the dilatation of the small bar, the degree of heat which has been applied to it may be determined. Such is the construction of Muschenbroeck's pyrometer. It is necessary to observe, that a small cup is adapted to the machine, in order to receive the liquid or fused matters subjected to experiment, and in which the bar to be tried is immersed. When it is required to measure by the instrument a considerable degree of heat, such as that of boiling oil or fu-

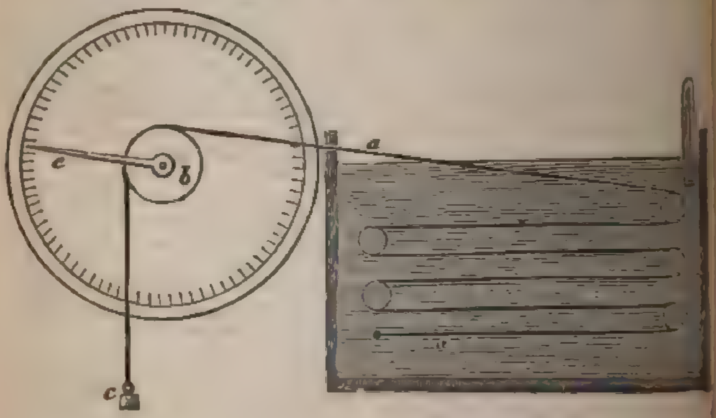
fill the cup with the matter to be tried, and immerse the bar of iron into The dilatation of the bar, indicated by the index, will point out the degree at it has assumed, and which must necessarily be equal to that of the into which it is immersed. This machine evidently serves to determine atio of the dilatation of metals, &c.; for by substituting in the room of the metric bar other metallic bars of the same length, and then exposing them equal degree of heat, the ratios of their dilatation will be shown by the of the index.

most celebrated instrument for measuring very high temperatures, is that ted by the late Mr. Wedgwood, founded on the principle, that clay pro-vely contracts in its dimensions, as it is progressively exposed to higher es of heat. He formed white porcelain clay into small cylindrical pieces, mould, which, when they were baked in a dull red heat, just fitted into the ing of two brass bars, fixed to a brass plate, so as to form a tapering space en them. This space is graduated, and the farther the pyrometric guage ater the greater heat does it indicate. The limits of the converging scale are tenths of an inch at the beginning towards the opening, and three-tenths at nd, or towards the line to which the bars converge. The next thing to be , was to ascertain and establish a connexion between the indications of his ument and those of the mercurial thermometer; to accomplish this, he oyed a heated rod of silver, of which he measured the expansion. The piece and the silver rod were heated in a muffle, and as soon as the muffle ted a low red heat it was drawn forward towards the door of the oven; s own door being then nimbly opened by an assistant, Mr. Wedgwood ed the silver rod as far as it would go. But as the division to which it ed could not be distinguished in that ignited state, the muffle was steadily and ously lifted out, and left to cool. When the muffle was sufficiently cold to be oved, the degree of expansion at which the silver stood was carefully noted, the degree of heat shown by the clay pieces was measured by their own ; after which, the whole was returned into the oven, and exposed to a intense heat, in order to obtain another point of correspondence between o scales, the graduated silver rod serving as an intermediate scale, with Wedgwood's and Fahrenheit's might be readily compared. The first of points of correspondence was $2\frac{1}{4}^{\circ}$ of Wedgwood's, to 1370° of Fahren-; the second was $6\frac{1}{4}^{\circ}$ of Wedgwood's, to 1890° of Fahrenheit's. Hence, $6\frac{1}{4} - 2\frac{1}{4} = 4$, and $1890 - 1370 = 520$, it appears, that an interval degrees on Mr. Wedgwood's instrument is equivalent to 520 degrees on of Mr. Fahrenheit's, and consequently, that 1 degree of the former equals of the latter, and the zero (or o) on Wedgwood's scale corresponds with and a fraction on Fahrenheit's. Hence, we have the means of reducing degrees at any point of one scale, to the corresponding degrees on the through the entire range. Mr. Wedgwood's instrument includes an t of about 31,200 of Fahrenheit's, or about 50 times that between the ng and boiling points of mercury, by which points the performances of mal thermometers are necessarily limited. Also, if we conceive Mr. wood's scale to be extended downwards below his zero, as Fahrenheit's is ed to extend upwards above the boiling point of mercury, the freezing of water will fall on 8°.421, or somewhat above $8\frac{1}{4}^{\circ}$ below the zero of wood's scale, and that of mercury on 8°.596, or a little below $8\frac{1}{2}^{\circ}$; so the distance between the freezing points of mercury and water is an inter-of .175 of a degree on Wedgwood's scale; 8° and a decimal from the freezing of water to complete ignition; and 160° is the highest point or degree of to which our ingenious philosopher was able to extend his observations.

Since dry air," observes Dr. Ure, "augments in volume three-eighths for egrees, and since its progressive rate of expansion is probably uniform by n degrees of heat, a pyrometer might easily be constructed on this prin—form a bulb and tube of platinum, of exactly the same form as the mometer, and connect with the extremity of the stem, at right angles, a tube of uniform calibre, filled with mercury, and terminating below in a ed bulb, like that of the Italian barometer. Graduate the glass tube into

a series of spaces equivalent to three-eighths of the total volume of the capacity of the platina bulb, with three fourths of its stem. The other fourth may be supposed to be little influenced by the source of heat. On plunging the bulb and two-thirds of the stem into a furnace, the depression of the mercury will indicate the degree of heat. As the movement of the column will be very considerable, it will be scarcely worth while to introduce any correction for the change of the initial volume by barometric variation; or the instrument might be made with the recurved bulb sealed, as in Professor Lesslie's differential thermometers. The glass tube may be joined by fusion to the platina tube. Care must be taken to let no mercury enter the platinum bulb. Should there be a mechanical difficulty in making a bulb of this metal, then a hollow cylinder, of half an inch diameter, with a platinum stem, like that of a tobacco pipe, screwed into it, will suit equally well.

A very convenient pyrometer for ascertaining the relative expansibility of the various metals that can be drawn into wire, was contrived by Mr. Gurney, which he employed in his chemical lectures. It is represented in the subjoined cut. *a* represents a wire of the metal to be examined, attached at the lower end to a peg fixed upon a piece of board; on this board is also a series of little pulley-wheels, turning freely on their axes, and around the peripheries of these wheels the wire is carried to the uppermost, whence it is conducted out of



the vessel, and over a small central wheel *b*, of a circular graduated scale, and with a weight *c* tied to this end of the wire, which keeps it in a state of tension. Thus prepared, the apparatus is immersed in a vessel of water, or other fluid, heated to the desired temperature within their capability, which is determined by a thermometer placed therein. The expansion which then takes place is accurately denoted by the index *e* pointing it out upon the graduated circumference, the index turning round as the elongation takes place. Upon abstracting the heat, the wire contracts and draws back the wheel and index to its previous position. An instrument of this kind, carefully constructed, and with a smaller central wheel *b*, would, without doubt, show the expansibility of the ductile metals with great exactness, and very satisfactorily, as the wire may be of great length, be wound round a large number of pulleys, so as to cause an obvious elongation of an inch or more.

PYROPHORUS. An artificial product, which takes fire upon exposure to the air, and hence called air-tinder. It is prepared from alum by the addition of various inflammable substances. The simplest mode of preparing it is to mix three parts of alum with one of wheat flour, and calcine them in a phial or mattrass, until the blue flame disappears, then keep it in the same phial the

sed, well stopped with a good cork. If this powder be exposed to the atmosphere, the sulphuret attracts moisture from the air, and generates sufficient heat to kindle the carbonaceous matter mingled with it.

PYROTECHNY is, properly speaking, the science which teaches the management and application of fire in various operations; but in a more limited sense, and as it is more commonly used, it refers chiefly to the composition, structure, and use of artificial fireworks. The ingredients are, 1. saltpetre, purified for the purpose; 2. sulphur; and 3. charcoal. Gunpowder is likewise used in the composition of fire works, being first ground, or, as it is technically termed, mealed. Camphor and gum benzoin are employed as ingredients in odoriferous fireworks. The proportions of the material differ very much in different fireworks, and the utmost care and precaution are necessary in the working them to a state fit for use, and then in the mixing. In this work we cannot enter on the subject with a sufficient degree of minuteness to teach the method of manufacturing fireworks, and shall therefore content ourselves with a brief notice of the proportions of the materials in some of the more common and more interesting articles in use. The charges for sky-rockets are made of saltpetre, four pounds; brimstone, one pound; and charcoal, one pound and a half; or by another direction—saltpetre, four pounds; brimstone, one pound and a half; charcoal, twelve ounces; and mealed powder, two ounces. These proportions vary according to the size of the rocket; in rockets of four ounces, mealed powder, saltpetre, and charcoal, are used in the proportions of 10, 2, and 1; but in very large rockets, the proportions are saltpetre, 4; mealed powder and sulphur, 1 each. When stars are wanted, camphor, alcohol, antimony, and other ingredients are required, according as the stars are to be blue, white, &c. In some cases gold and silver rain is required; then brass-dust, steel-dust, sawdust, &c. enter into the composition; hence the varieties may be also indefinite. With respect to colour, sulphur gives a blue, camphor a white or pale yellow, saltpetre, a clear white yellow; sal-ammoniac, a green; antimony, a reddish; resin, a copper colour.

Q.

QUADRANGLE. A figure containing four angles and four sides.

QUADRANT, in Geometry, the quarter or fourth part of a circle, and therefore containing an angle of 90 degrees.

QUADRANT also denotes a mathematical and optical instrument, of great use in navigation and astronomy, for taking the altitude of the sun and stars.

QUADRAT, in Printing, is a piece of metal cast like the type, to fill up the spaces between words; they are made of different sizes, called by the space they occupy, as *m* quadrats, *n* quadrats, &c.

QUARRY. A cavity or opening made by miners in rocky ground, from which are procured marble, freestone, slate, limestone, or other materials; one of which, in the island of Jersey, is represented in the subjoined cut; from whence is obtained large quantities of stone for the London pavements. It is of essential importance that such works should be situated close to the sea, or a river, or canal, for the convenient and cheap transport of the heavy product, as it is the cost of carriage which constitutes its chief cost. The mode of separating the stone from the rock differs according to its natural formation; but in granite and other hard rocks of continued solidity, the process, though apparently difficult, is extremely simple, as it consists chiefly in boring holes with proper instruments, (which have been described, as well as the process, under the word BLASTING;) then ramming into the hole a charge of gunpowder, laying a train to it, firing the train, and retreating to a distance or under an overhanging cliff to avoid the stones which are thrown up by the explosion.

The holes are made from one to three feet in depth, and generally about an inch diameter; but these, as well as the position and direction of the perforation, and also the charge of the powder, are subject to the skill and discretion of the miner. The rules by which he is guided are, to direct the effort of the explosion to a part of the rock which is most easily displaced, and to proportion the charge to the effect required, so as to shake and loosen a larger portion

than to blow out a less quantity. The danger of beating the tamping has iron tools in hard rock, and the many dreadful accidents that frequently happen in this operation, have led to the introduction of contrivances to diminish risk; but though some of these have been well adapted for the purpose, yet they occasion a little more trouble, they have not been generally adopted by the miner. The simplest and best precaution against danger, is to have the of copper, instead of iron; but as the former is not so easily made or repaired by the smiths on a mine as the latter, they are not so well liked by the work. Another mode of preventing danger in tamping, is by employing substances to confine the gunpowder which require little or no force in beating them the hole; and as dry sand will often serve the purpose if the rock is not hard, it may be sometimes used; but there are many cases in mines where will not succeed, and therefore it is seldom attempted. A better substance confine gunpowder in holes, is good tough clay, and this will answer in cases where sand will fail, particularly in wet ground, or in holes that are clined upwards; it will produce the proper effect in all but very hard rocks, if the men could be induced to use it, would undoubtedly tend to the saving many lives.

An instrument, denominated by the inventor, the "*Miner's Safety Fuse,*" patented in 1831 by Mr. Bickford, of Tucking Mill, Cornwall; which may briefly described as consisting of a minute cylinder of gunpowder, or suitable explosive mixture, enclosed within a hempen cord, which is first tw in a peculiar kind of machine, then countered or overlaid to strengthen it, wards varnished with a mixture of tar and resin, to preserve the combu matter from the effects of moisture, and finally coated with whitening, or light pulverulent matter, to prevent the varnish from sticking to the finger the fuses to one another. These fuses appear, from the specification, to be judiciously and accurately prepared, and will, we doubt not, be found of utility in mining operations.

For facilitating the operation of boring rocks, a patent has lately been

n the United States of America, which is thus described in the *Journal of* *ranklin Institute.* "A frame is made, in the centre of which an iron shaft od is caused to rise and fall vertically between friction rollers, so placed as ep it in its position. In the lower end of this shaft, a socket is formed, to ve drills of different sizes. Provision is made for placing the machine ally, by sliding pieces upon each of its four legs, which serve to lengthen n as may be necessary. The apparatus for working the shaft up and down, med as follows: a circular plate of iron, about a foot in diameter, has a in its centre, provided with a socket adapted to the iron rod or shaft, and ble of being secured at any part of it, so that the plate will stand horizon-. At a little distance from the periphery of this plate, an iron spindle es the frame; upon this spindle are lifters, which, as it is turned by a k, come in contact with the lower side of the plate, and raise the shaft; on rollers are contained within the lifters, to cause them to slide easily upon plate, and their action is so managed as to produce a small revolution of the , and consequently of the drill, at every lift."

e term *quarry* is likewise given to a variety of neatly formed bricks, tiles, tones, with very level surfaces, and of diversified colours; which are em- d in many parts of England, as well as other countries, for making plain rnamental flooring. The perforated tiles employed in malt-kilns, some of drying stoves, and for various other uses, receive this denomination. provement in the construction of quarries, applicable to kilns for drying wheat, and other grain, was lately patented by Mr. Henry Pratt, (a gentle- of great skill and knowledge in such subjects,) of Bilston, in Staffordshire; culiarities of which may be thus briefly explained. Instead of the usual openings, terminating in small circular apertures in the flooring of grain Mr. Pratt forms his quarries for such purposes of cast-iron, in pre- e to baked clay, having oblong slots or openings at the tops of rectan- tapering holes, which are designed for the escape of the heated air. He his quarries with strengthening bars projecting from their lower sides, and bars form the sides of the tapering channels as well as give sufficient gth with a less quantity of material than is required when the quarries made of an uniform thickness.

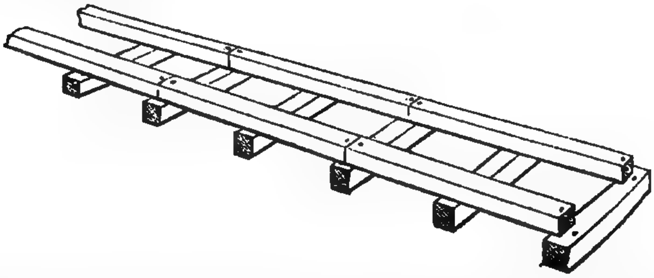
ARTATION. An operation by which the quantity of one thing is equal to the fourth part of the quantity of another thing. Thus, when gold ed with silver is to be parted, we are obliged to facilitate the action of the ortis by reducing the quantity of the former of these metals to one-fourth f the whole mass; which is done by sufficiently increasing the quantity silver, if it be necessary. This operation is called quartation, and is pre- tory to the parting; and even many authors extend this name to the opera- of parting.

ARTZ. A mineral of the flint genus, which is divided into five sub- n by Professor Jameson; namely, the amethyst, the rock-crystal, milk tz, common quartz, and prase.

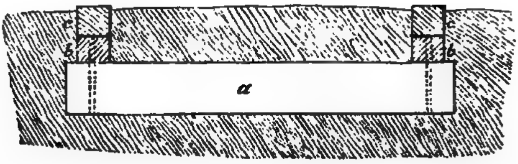
ICKLIME. A hot caustic substance, employed in the composition of ar for buildings; by farmers, as a manure; by bleachers, tanners, sugar- rs, soap-boilers, and iron-masters, in the preparation of various manufac- and also in medicine. Quicklime is obtained from chalk, marble, lime- oyster shells, &c. by expelling from them, by means of heat, the carbonic and water with which they are combined. The quantity of quicklime ned from a ton of limestone, if weighed when hot from the kiln, is on an ge, according to the experiments of Bishop Watson, 11 cwt. 1 qr. 4 lb. By ure to the air also, a ton of quicklime acquires daily the additional weight bout one twentieth part of itself, for the first five or six days after it is n, and therefore, the earlier it is used the better. Quicklime, to be reserved emical or medicinal uses, should be kept in bottles well stopped.

ICK-MATCH. A combustible preparation, formed of cotton strands, n into length, and dipped into a boiling composition of vinegar, saltpetre, mealed powder. After this immersion, it is taken out hot, and laid in a , where some mealed powder, moistened with spirits of wine, is thoroughly

the line; and this improvement was distinguished by the term of a "double-way," in contradistinction of the former plan, afterwards denominated the "single-way."



In the single-way above delineated, it should be observed that the ends of the successive rails necessarily met on a sleeper to which they were fastened; but owing to the continual concussions they were subjected to, not only by the loaded waggons, but by the feet of the draught horses, they soon became loosened, worn out, or otherwise deranged. By fixing another rail above the former, which might be of any length, and be fastened to it in any part, it not only much increased the strength of the whole, but defended the substructure from wear; while the upper, or covering rail when worn out might be renewed without materially disturbing the under. The double-rail also, being more elevated from the ground, admitted of a greater depth of cinders, or other hard substance, in order to form a more solid and durable road for the waggons and horses. The annexed diagram, which is designed to exhibit a cross section of the road, will make this matter clear. At *a* is one of the sleepers, which lie



about two feet apart across the road, throughout its entire length: *b b* show the ends of the under rails, which are cut of a uniform length, so as to rest upon three sleepers; so much constituted the single-way before delineated. At *c c* are the upper or covering rails, which may be of the length of the whole balk, and be fastened wherever convenient to the under rails; and this addition constituted it into a "double-way," which term might reasonably be supposed to imply a double road, instead of a single one. Railroads of the last described kind continued in use for many years in the collieries of the north of England; and a horse was found competent to draw three tons of coals upon them. The waggons used were nearly of the present construction; but their wheels of so small a diameter, as to be generally termed "rollers." At the declivities, significantly called *runs*, brakes were employed to retard the progress of the waggons. To avoid descending from the high banks near the river, high platforms, called *staiths*, were erected, projecting over the water. On to these staiths the waggons were run by a slightly inclined plane, and there discharged through spouts either directly into the holds of ships moored underneath, or into capacious intermediate reservoirs conveniently planned for the subsequent loading of ships.

In most cases the wooden railroads, from the mine to the place of shipment were made so as to follow very nearly the undulations of the country over which they passed; excepting only here and there at very steep ascents; and for a long period of time no attempts were made to counteract the rapid descent of

the carriages down the declivities, except by means of brakes, which, depending wholly upon the strength and dexterity of the waggoners, often failed, and were productive of many sad accidents. When cast-iron wheels were first introduced, they were only used for the fore-axle, the wooden wheels being retained on the hind-axle, from the idea that the brake could only be applied effectively to the wooden wheels. At length it was contrived, by an extension of the lever, to apply a brake to the metallic; and then all the four wheels were made of iron. The next improvement was the substitution of iron rails for wood, which alone enabled the horse to take double his previous load.

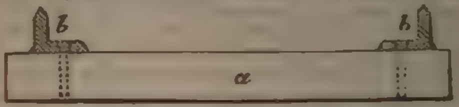
The adoption of cast-iron plates to cover and strengthen the wooden fabric, was the first application of metal to railways; and this was effected by the Colebrook-dale Company, at their iron works in Shropshire, in 1767. This information we derive from a published letter of the ingenious Hornblower, the contemporary of the celebrated Watt; wherein he says, "Railways have been in use in this kingdom time out of mind, and they were usually formed of scantlings of good sound oak, laid on sills or sleepers of the same timber, and fixed together with the same stuff. But the proprietors of Colebrook-dale Iron Works, a very respectable and opulent company, eventually determined to cover these oak rails with cast-iron, *not altogether as a necessary expedient of improvement, but in part as a well-digested measure of economy in support of the trade.* From some adventitious circumstances, (which I need not take me to relate,) the price of pigs became very low, and their works being of great extent, in order to keep the furnaces on, they thought it would be the best means of stocking their pigs, to lay them on the wooden railways, as it would help to pay the interest by reducing the repairs of the rails; and if iron should take any sudden rise, there was nothing to do but to take them up, and send them away as pigs. But these scantlings of iron (as I may call them) were not such as those which are now laid in some places; they were about five feet long, four inches broad, and one inch and a quarter thick, with three holes, by which they were fastened to the rails, and very complete it was both in design and execution. Hence it was not difficult, if two persons on horseback should meet on this road, for either to turn his horse out of the road, which, on the railways now introduced, would be attended with some serious doubt as to the consequences. *But it would be impossible on the best railways to afford that facility of travelling which we now enjoy on a spacious well-managed road.*" Such a man as Hornblower would never have hazarded this prediction, had the plans for locomotion on rails as now developed, been submitted to him as an query, for his opinion of their feasibility.

The introduction of metallic surfaces to wooden rails was, however, at first productive of serious evils, for the resistance of, or adhesion to the surface in descending inclined planes was thereby so much lessened, that the ordinary brake was found to be quite ineffective in counteracting the force of gravity. Recourse was therefore had to the double self-acting inclined planes, by which the surplus power of gravity of the load descending one plane, was employed to drag up the empty waggons on the ascending plane. As the acting principle of mechanism of this kind is so very simple and obvious, we shall not detain the reader by describing any of their details in their pristine state, but refer him to the matured plans of more recent times, which will be described hereafter in their proper place.

We now come to the period 1776, when cast-iron plates were used, not as coverings to wooden rails, but in the place of the rails themselves; such plates having cast to them an upright ledge, to keep the carriage wheels from running off them. These plates, being used by the waggons called trams, acquired, and have ever since been distinguished by the term "tram-plates." They were the subject of a patent granted to Mr. Carr, of the Sheffield Colliery, and were evidently an important improvement, as from the date of the patent to the present time, they have been in constant requisition to an immense extent, both on the surface, and in mines. The form given to them, as used in the above-named colliery, is delineated in the following transverse section. *a* represents an oaken sleeper; *b b* the tram-plates of cast-iron, which are about six

feet long, and fastened down at each end and in the middle to three parallel sleepers. In situations where stone is less valuable than timber, blocks of that material are substituted.

The mode of fastening down tram-plates by bolts or spikes was found to be attended with several inconveniences, owing to the occasional projection of their heads, their becoming loose, and hence both the plates and bolts being frequently stolen, to the entire stoppage of the traffic upon the road. To remedy these evils, Mr. Charles le Caan, of Llanelly, in South Wales, contrived a mode of forming the plates, so that no bolting or nailing was requisite, but each plate



in succession fastened down the previous one. *Fig.* 1 represents a plan of the junction of two plates, placed on a stone sleeper D; and *Fig* 2 shows a longitudinal section of the same. The plates are joined by a dove-tailed notch and tenon, and an oblique plug is cast on each plate, which is let into the stone sleeper; but for the advantage of taking up the plates to repair any defect, there are plates at every thirty yards, with perpendicular plugs; such plates are called stop-plates. The diameter of the plug near the shoulder is one inch and three quarters, at the point one inch, its length two inches and a half, and its obliquity, shown in *Fig.* 2, about eight degrees. A small groove in the whole length of the exterior of such plug is made to allow the water in the hole to expand in freezing; and it also serves to admit a wire to draw a broken plug out by it. The holes for the plugs should be cut to the depth of three inches by a standard gauge of cast-iron, and countersunk so as to allow the end of the plate to bed firmly on the block which supports it. *Fig.* 3 is one of the

Fig. 1.

Fig. 2.

Fig. 3.

ends of a tram-plate, in which H shows the flange or upright edge; I the flat part or sole, in which the wheels of the waggon run; D one of the plugs, and K a projection behind, to render the plates firmer upon the blocks. The usual length of one plate is three feet; the flanch H is one and a half inch high, the sole, or bed, three and a half, or four inches broad, and three fourths of an inch thick; but these dimensions are varied according to circumstances. The most approved weight has been forty-two pounds for each plate; the ends from which the plugs project, under which the tenons and notches are made, should be a quarter of an inch thicker than the other parts of the plate. The weight of the blocks or sleepers should not be less than about 120 pounds each, and some kinds of ground will require heavier. In this method the wheels of the waggons cannot be obstructed by the heads of the nails rising above the surface, and the blocks are not disturbed by fixing the plates; and when repairs are necessary, the plates must be formed for the purpose. When tram-plates are fixed by spikes to stone sleepers, there is some difficulty in keeping the joint even and in its place; but it seems to be successfully obviated by using a saddle-pin to receive the ends of the nails at the joints, an improvement which was introduced by Mr. Wilson on the Troon tramroad.

Tramroads are much esteemed in Wales; and in consequence of using them it is found desirable to divide the pressure upon the rails as much as possible; hence, small carriages are used, and these lead to small wheels, so that the effect of a given power is not above half what it ought to be; and yet the enormous increase of railroads in Wales renders it evident that some benefit is received from adopting this system of conveyance. In 1791, there was scarcely a single railway in South Wales; and in 1811, the complete railroads connected with

canals, collieries, &c. in Monmouthshire, Glamorganshire, and Caermarthenshire, amounted to nearly 150 miles in length, exclusive of under-ground ones, of which one company in Merthyr Tydvil possessed about thirty miles; since which period the lines have been extended to, at the least, five hundred miles.

It now becomes proper to introduce some notice of *edge* rails, the use of which is so generally and justly preferred to the tram plate. Their origin it would be difficult to trace with any precision; and it is a question of so little moment, as to be hardly worth the trouble of investigation. Some of the wooden rails partook of the usual shape, especially when capped with a plate of iron: hence a transition to more judicious forms and more permanent materials was easy.

The earliest complete edge rail which we know of was made of *cast*-iron, in 1789, by Mr. Jessop, at Loughborough, the upper surface of which was flat, and the under of an elliptical shape. But this appears to have been so little known to engineers, that we find Mr. Benjamin Wyatt making use of a cast-iron edge rail in 1800, and imagining himself to be the inventor. The form of his rail was indeed quite original, and ought not therefore to be omitted in this sketch. It is thus described by himself:—

"The rail hitherto made use of in most railways is a flat one, 3 feet in length, with a rib on one edge, to give it strength, and to prevent the wheels, which have a flat rim, from running off. Observing that these rails were frequently obstructed by stones and dirt lodging upon them; that they were obliged to be fastened to single stones or blocks, on account of their not rising sufficiently above the sills to admit of gravelling the horse path; that the sharp rib standing up was dangerous for the horses; that *the strength of the rail was applied the wrong way*; and that less surface would produce less friction: led me to consider if some better form of rail could not be applied. The *oval* presented itself as the best adapted to correct all the faults of the flat rail, and I have the satisfaction to say that it has completely answered the purpose in a railway lately executed for Lord Penrhyn, from his lordship's slate quarries in Caernarvonshire to Port Penrhyn, the place of shipping. The wheel made use of on these rails, has a concave rim, so contrived in its form, and the wheels so fixed upon their axes, as to move with the greatest facility on the sharpest curves that can be required." In the annexed section, *a* represents

the rail, which is 2 inches deep and 1½ inch thick horizontally; the lower part, *b*, is cast to each end of the rail, 3 inches long, to let into the sills, which have a dove-tailed notch to receive them. The advantages of this form were said to be, that no dirt can lodge upon it; that it is strong for its weight, and calculated to resist both the lateral and perpendicular pressure; that it must occasion but little friction; that it may be placed on the sills so as to admit a sufficient quantity of gravel to cover them, and present no danger to the horses. They were cast 4 feet 6 inches long, and weighed 35 pounds each.

The Penrhyn railway is six miles and a quarter in length, divided into five stages. It has three-eighths of an inch fall in a yard, with three inclines; was begun in October 1800, and finished in July 1801. The annexed sketch

shows the kind of waggons that were used on this railway, twenty-four of which, containing 24 tons, were drawn by two horses (one stage) six times a day; which is 144 tons per day, drawn 6¼ miles per day. This quantity of work was

previously performed by 144 carts, and 400 horses: so that *ten* horses will by means of this railway do the work of *four hundred!*

It was however found that the oval-formed rail had a tendency to wear the concave rims of the wheels very fast into hollows, which fitted so tight upon the rail as to create great friction, and render it necessary to change the wheels very often. It was accordingly proposed to substitute for them a rail and wheel

represented in the annexed cross section: *a* is the rail, *b* the dovetail, *c* the lower ends of the wheels, and *e* the sills, now made of cast iron.

SECOND ERA.

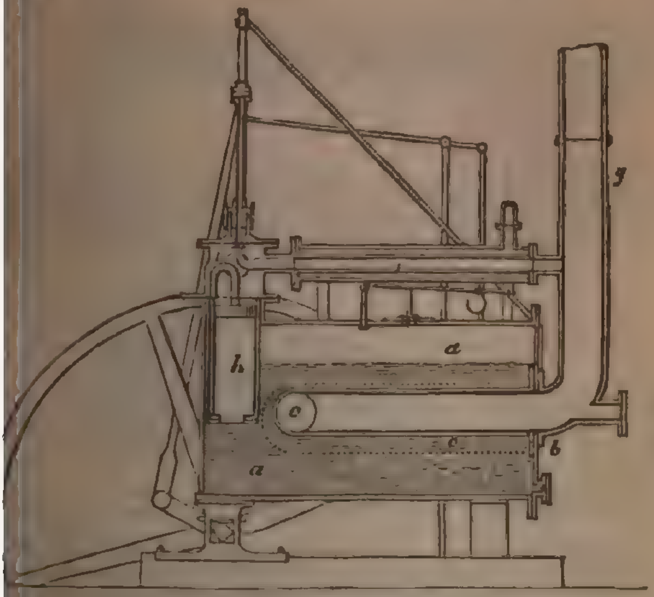
To Trevithick and Vivian, who were engineers at Camborne, in Cornwall, belongs we believe the honour of having invented and carried into practice locomotive engines. This single event forms an era, not only in mechanical science, but also in our social relations; as it is calculated to bring about a more extensive and beneficial change than almost any other event on the page of history, by placing the arts, sciences, knowledge, conveniences, comforts, manufactures, and produce, peculiar to each remote place or district within the reach of all.

We should not omit to notice, that the possibility of applying the power of the steam engine was mentioned by several mechanics, soon after it was brought into a practicable form by Savery, Newcomen, and others, in the early part of the last century; and towards the latter part (1784), the celebrated James Watt *mentioned* the subject in his specification of that date, seemingly with the view of *recording* himself as the inventor; but he never *built* a steam carriage; and the machine which he suggested under his general patent, was designed for a common road. "A carriage for *two persons, might* (he observed) be moved by a cylinder of seven inches in diameter, when the piston had a stroke of one foot, and made sixty strokes a minute." In a note to a late edition of Dr. Robison's mechanical Philosophy, Mr. Watt states: "I soon relinquished the idea of constructing an engine on this principle, from being sensible it would be liable to some of the objections against Savery's engine, viz. the danger of bursting the boiler, and also that a great part of the power of the steam would be lost, because no vacuum was formed to assist the descent of the piston." This extract affords clear evidence of two important facts. The *first*, that Mr. Watt did not entertain the idea of applying his crude scheme to railways, although there were many in active operation in the North of England, and some in Wales. The *second* fact is, that Mr. Watt acknowledged the incompetency of his own scheme to effect the object designed.

In the formidable qualities which had excited the fear of Watt and others, Trevithick and Vivian perceived those very properties which fitted it to become the actuating principle of their mechanism. Above all other considerations which swayed them in the preference of steam of a high temperature, was the power it gave of dispensing with the use of the condenser altogether; a

rom its cumbrousness, and the difficulty of supplying it with water, it far inferior even to Newcomen's imperfect apparatus for locomotive

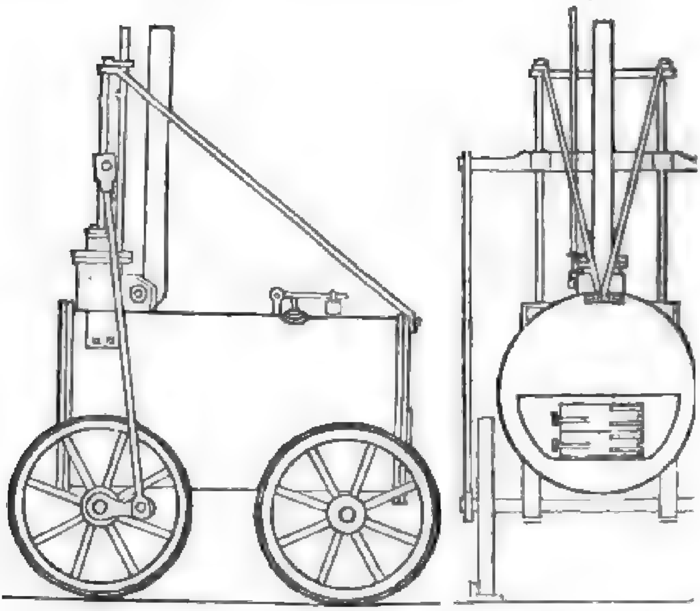
unprovided with an authentic drawing of Trevithick and Vivian's e, we will endeavour to explain its arrangements with such diagrams e in our possession. The annexed, we are informed, is a sectional om one of their engines, containing the same leading features as their re.



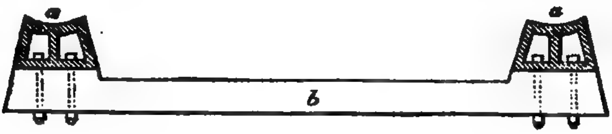
is a cylindrical boiler, with a fire door at *b*, at one end of the cylinder; fire-place, from which proceeds the principal flue, the parts being dots, as they are supposed to be situated on one side of the vertical ough which our section is made; the flue, therefore, is turned at the en recurved and continued to the chimney *g*. This arrangement of nd flue within the boiler has been ever since distinguished by the inventor, Trevithick, and has been more used than any other, on its economy in the consumption of fuel. The lower part of the ylinder *h* is immersed in the boiler, and the upper has a jacket, ich the fresh hot steam circulates freely, so that no loss of power ioned by the cooling influence of the air upon the cylinder, as was the case. Above the cylinder is the four-way cock *i*, for admitting ging the steam alternately; in the latter operation the waste steam rged along a pipe, *j*, into the chimney, which, by increasing the rough the fire, augments the production of steam, and gets rid of the f the waste steam, in a manner so desirable as to render it now indis- The upper end of the piston rod is furnished with a cross head, which a direction at right angles to the length of the boiler, and parallel her. To the ends of this cross head are joined two connecting rods, ends of which work two cranks, fixed in the extremities of the axis ries the running wheels, the axis extending across and beneath the immediately under the centre of the steam cylinder. This arrange- own in *Fig.* 1 of the following diagrams, extracted from Mr. Gordon's n "Elemental Locomotion," which states it to be an end elevation

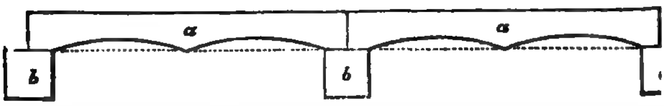
of Trevithick and Vivian's locomotive engine; and *Fig.* 2 a side elevatio[n] the same. • Mr. Gordon has, however, omitted the chimneys, and has sh[own] the eduction pipe as discharging the steam directly into the atmosphere.

Fig. 2. *Fig.* 1.



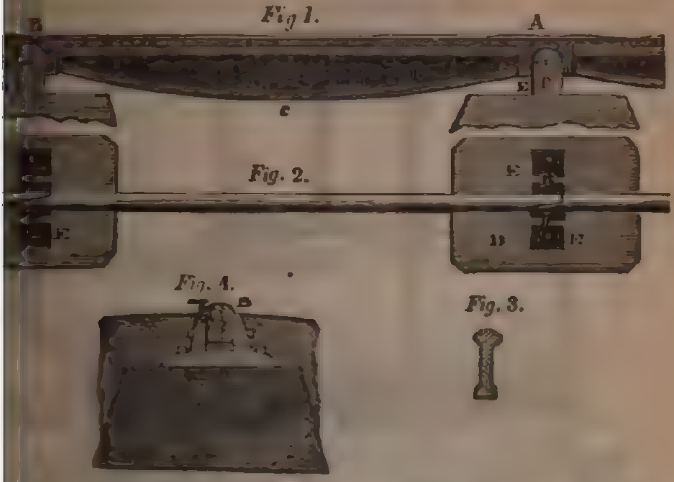
The next invention which we have to notice, in accordance with our chr[ono]logical order, is that of an improved cast-iron rail or plate, which has [been] proved in numerous situations to be highly useful; it was patented by J. Woodhouse, of Ashby-de-la-Zouch, in 1803. The specification desc[ribes] various modifications of the plan, showing its application to gravelled r[oads,] paved roads, or streets, and to railways. But the following diagram will s[uffice] to show its application to the latter object, and its adaptation to the [other] objects may be as readily conceived. At *a a* is the rail or plate, the u[pper] surface of which is made concave, as shown in the section in *Fig.* 1.





length of these rails or plates is shown at *a a* in the elevation *Fi[g.]* and the mode of supporting and fastening their ends on two bearers or sl[eepers] *b b b*. The bearings may be made of timber, stone, or cast-iron or wood and the plates fixed by screw or cotter bolts. The road is to be made even

d materials, and the rails will then, the patentee states, be immovable. kewise intended to use the said hollow rails or plates as water-conduits s, to which object they have been frequently and are now applied in rts of London and elsewhere. Indeed, the design is so complete, as to elf, with slight alterations, to many situations and purposes.
provements effected on the Penryhn railway before mentioned naturally eliorations in the structure of similar works elsewhere, which was



y observable on the banks of the Tyne and Wear. The expense of the f coals forms so considerable a proportion of their money cost, that the re always alive to any decided saving that may be effected therein. ngravings above, *Fig.* 1 represents a side view, *Fig.* 2 a plan, and *Fig.* 3 ection of a *cast-iron* edge-rail, of the form which has been extensively in the districts above mentioned. The waggons run upon the rounded the rail, which is smooth, and laid as evenly and regularly as possible. th of these rails is usually three feet, with a depth of about four inches alf in the middle, and breadth of the top two inches; but in some the rails are four feet long. The ends of the rails meet in a piece of called a chair (see *Fig.* 4), and the chairs are fixed to stone blocks or with a broad base, and weighing from one and a half to two hundred These are firmly bedded in the ground, and adjusted to a proper plane and before the chairs are connected to them. The goodness of the ourse depends much on fixing the sleepers in a sound, firm manner. the side view of the rail C is shown, supported at the extremities A B ron chairs E E, which rest on the stone blocks, or sleepers, D D. he plan, shows the scarf joints, where the ends of the rails meet in the rs E E. *Fig.* 3, the cross section of the rail taken at C, in *Fig.* 1, the middle of its length. *Fig.* 4 is a cross section at B, through the r and supporting blocks.
this period in the history of railways, it does not appear that any wer of draught or propulsion was employed but that of horses, except, lly, of fixed engines at inclined planes.
year 1811, a patent was taken out by Mr John Blenkinsop, coal viewer, ton, in Yorkshire, for "certain mechanical means by which the con- of coals, minerals, and other articles is facilitated, and the expense the same rendered less than heretofore." The specification of this forms us that it consists of the application of a rack or toothed rail, on one side of the roadway from end to end. Into this rack a

toothed wheel is worked by the steam-engine; the revolution of which whe[el] produces the necessary motion, without being liable to slip in descending [a] steep inclined plane.

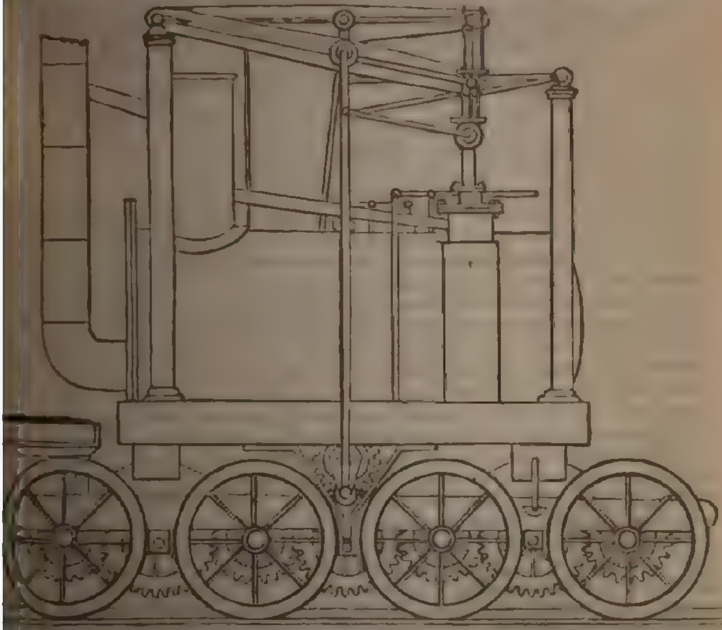
The accompanying figure will convey to our readers an idea of Mr. Blenkin[-]

sop's plan. The boiler *x* is placed on a wooden or cast iron frame *y*. Throu[gh] its interior passes a wrought-iron tube, of sufficient diameter to hold the [fire] and grate; this tube is carried out at the farther end of the boiler, when it [is] bent upwards, and continued sufficiently high to form the chimney *z*. *a a* a[re] two working cylinders fixed in the boiler, and which work in the usual way; the piston rods are connected by cross heads to the connecting rods *b b*. Th[e] connecting rods are brought down on each side of the boiler, and there joi[ned] to the cranks *c c*, (there being corresponding cranks on the other side of t[he] machine,) which are placed at right angles to each other; consequently the t[wo] cranks on the first shaft are horizontal, and at their greatest power, at the ti[me] the other two are passing the centre. Upon these shafts are fixed (under t[he] boiler) two small toothed wheels, which give motion to a larger toothed wh[eel] fixed upon an intermediate axis. A toothed wheel *f* is firmly keyed to the s[haft] of the same and revolves with the intermediate wheel. The teeth of *f* corresp[ond] with, and work into a rack R R, stretched along one side of the rail[-] Motion, therefore, is given by the pistons to the wheels *d d*, which they co[m-] municate to the cog-wheel *f*: a progressive movement being given to [the] carriage by the teeth of *f* taking hold of the rack.

The communication of the pressure of the steam upon the piston thro[ugh] the connecting rod and cranks, it is said, produced great noise, and in so[me] parts of the stroke great jerks, each cylinder alternately propelling or becom[ing] propelled by the other, as the pressure of the one upon the wheels bec[ame] greater or less than the pressure of the other; and when the teeth became w[orn] they produced a rattling noise. Mr. Galloway states that several of th[ese] engines were constantly employed in drawing coal-waggons between Middle[-]

ery and Leeds; and with reference to their effectiveness, the following par-
ars were given by Mr. Blenkinsop in reply to queries put to him by Sir
Sinclair. He stated that his patent locomotive engine, with two eight-
cylinders, weighs five tons; consumes two-thirds of a hundred weight of
, and fifty gallons of water per hour; draws twenty-seven waggons, weigh-
ninety-four tons, on a dead level, at three and a half miles per hour; or
n tons up an ascent of two inches in the yard; when lightly "loaded" it
els ten miles an hour, does the work of sixteen horses in twelve hours, and
s 400*l*.

the following year, 1812, Messrs. William Chapman, of Durham, and
W. Chapman, of Wallsend, Northumberland, took out a patent for "a
od or methods of facilitating the means, and reducing the expense of car-
on railways and other roads;" which they describe as chiefly consisting in
se of a chain, or other flexible and continuous substance stretched along
road to be travelled, properly secured at each end, and at suitable intervals;
in the application of this chain round, or partially round a grooved barrel
wheel, in such manner as not to slip when this grooved wheel, which is fixed
, before, or behind a carriage containing the motive power, shall be put in
on by that power, so that by the revolution of the grooved barrel round its
, either one way or the other, it shall necessarily draw the said carriage, and
others which may be attached to it, within its power of action. As the
riage containing the motive power, when thus loaded, may be too heavy in
e instances for the existing iron or wooden rails, if it rested on four wheels
, Messrs. Chapman proposed to use six or eight wheels, in order that they



t more freely move round curves in the road, and that the weight might be
distributed thereon; the pressure being thus reduced upon each bearing
, in the inverse proportion of the number of wheels. The means adopted
e patentees for carrying their invention into effect, are described at consi-
ble length, with explanatory drawings, in their specification; but as Mr.
d informs us that the application of it failed at the Heaton Colliery, where

it was for a time put into practical operation, and as the details of it would occupy too large a space in our pages, if inserted, we shall refer the reader to the enrolled document for them. The cause of the failure just mentioned is stated to have been owing to the waste of power arising from the excessive friction of the chain. There are one or two incidental observations in the specification which ought not perhaps to pass unnoticed. Allusion is made to the possibility of employing *inflammable gas* as the motive power, which, most of our readers are aware, was a few years ago carried into effect by the ingenious Samuel Brown. We also remark, although it is of little moment, that the specification contains the first proposition we have met with for employing the common winnowing machine to force a current of air under the fire-place. The annexed engraving exhibits an elevation of one of the locomotive engines of Messrs. Chapman, which was employed on the Heaton Colliery. The boiler consists of a large cylinder, of the Trevithick kind, with the furnace and a double or return flue passing through it to the chimney, situate on one side of the fire door; opposite to which is a chest containing the fuel of supply. The steam chamber is a large vertical cylinder, from which proceeds laterally a pipe to conduct the steam to two vertical cylinders, fixed on either side of the boiler. The motion of the piston rods actuated two vibrating beams, to which were appended two connecting rods, whose lower extremities worked two revolving cranks, carrying on their axis, spur geer, which, through the medium of a train of toothed wheels, shown, gave simultaneous motion to all the running wheels. The weight of this engine, with its water and fuel, we are informed was six tons; and it was set to work in December 1812, upon the railway leading from Mr. J. G. Lambton's collieries to the river Wear. It drew after it 18 loaded coal waggons, weighing 54 tons, up a gentle ascent rising $\frac{1}{48}$ of an inch to a yard (or 46 feet in a mile) at the rate of four miles an hour. The power of the engine was applied to the running wheels as already described; and it was found that their resistance to slipping upon the rails was the utmost power it could exert in drawing waggons after it, which in this instance was carried to the extreme; for although the friction was equal to the drawing forward the train of eighteen waggons, *after they were fairly in motion*, it did not overcome their *vis inertia* until after a considerable *slipping* of the wheels of the carriage.

We now come to the description of a machine of great singularity, and which strongly attests the ingenuity of the contriver, Mr. William Brunton, of the Butterly Iron works, in Derbyshire, and for which he took out patents. It consists in a curious combination of levers, the action of which nearly resembles that of the legs of a man in walking, whose feet are alternately made to press against the ground of the road or railway, and in such a manner as to adapt themselves to the various inclinations or inequalities of the surface. The following engraving represents this engine, which the inventor called his "MECHANICAL TRAVELLER." The boiler is nearly similar to that which we last described. The cylinder *a* is placed on one side of the boiler; the piston rod is projected out behind horizontally, and is attached to the leg *a b* at *a*, and to the reciprocating jointed bent lever above; at the lower extremity of the leg *a b* feet are attached by a joint at *b*; these feet lay a firmer hold on the ground, being furnished with short prongs, which prevent them from slipping; and are sufficiently broad to prevent their injuring the road. When the piston rod is projected out from the cylinder, it will tend to push the end of the lever, or leg *a*, from it, in a direction parallel to the line of the cylinder; but, as the leg *a b* is prevented from moving backwards by the end *b* being firmly fixed upon the ground, the reaction is thrown upon the carriage, and a progressive motion given to it, and this will be continued to the end of the stroke. Upon the first reciprocating lever is fixed at 1, a rod 1 2 3 sliding horizontally backwards and forwards upon the top of the boiler; from 2 to 3 it is furnished with teeth, which work into a cog-wheel, lying horizontally; on the opposite side of this cog-wheel a sliding rack is fixed similar to 1 2 3, which, as the cog-wheel is turned round by the sliding rack 2 3, is also moved backwards and forwards. The end of this sliding rod is fixed upon the other reciprocating lever of the leg *d e* at 4. When, therefore, the sliding rack is moved forwards in the direc

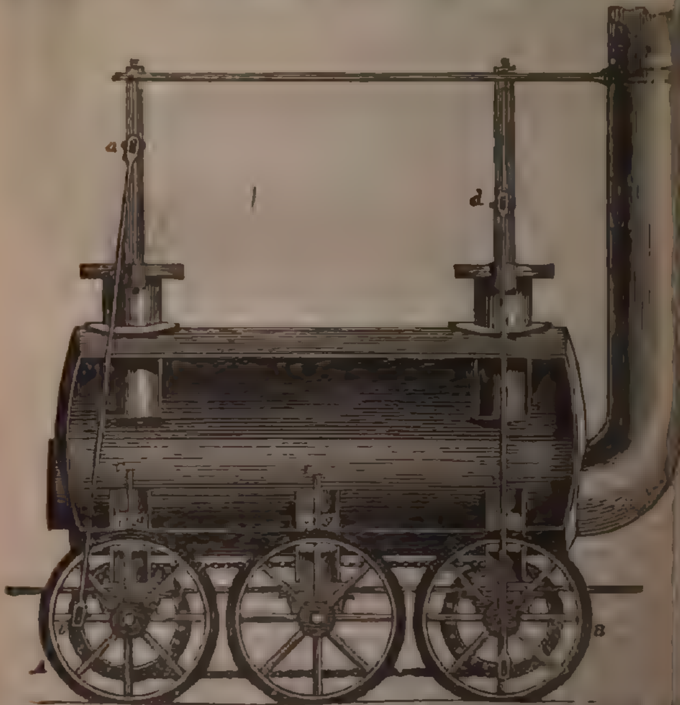
tion 3 2 1, by the progressive motion of the engine, and when the piston rod is at the farthest extremity of the stroke, the leg *d e* will be brought close to the engine; the piston is then made to return in the opposite direction, moving with it the leg *a b*, and also the sliding rack 1 2 3; the sliding rack acting on the tooth wheel causes the other sliding rod to move in the opposite direction, and with it the leg *d e*. Whenever, therefore, the piston is at the end of the stroke, and one of the legs is no longer of use to propel the engine forward, the

other, immediately on the motion of the piston being changed, is ready, in its turn, to act as an abutment for the action of the moving power to secure the continued progressive motion of the engine. The feet are raised from the ground during the return of the legs to the engine, by straps of leather or rope fastened to the legs at *f f*, passing over friction sheaves, movable in one direction only, by a ratchet and catch, worked by the motion of the engine.

The boiler was a cylinder of wrought iron, 5 feet 6 inches long, 3 feet in diameter, and of such strength as to be capable of sustaining a pressure of upwards of 400 pounds per square inch. The working cylinder was 6 inches in diameter, and the piston had a stroke of 24 inches, the step of the feet was 26 inches, and the whole machine, including water, weighed about 45 cwt. When placed upon a railway, Mr. Brunton found that it required to move it at the rate of 2½ miles per hour, a power equal to the constant pressure of 84 pounds. He then applied a chain to the hinder part of the machine, by which as the machine moved forward, a weight was raised at the same time and rate; and he found that with steam equal to 40 or 45lbs. pressure upon the square inch, the machine was propelled at the rate of 2½ miles per hour, and raised 112 lbs. at the same speed; thus making the whole power 896 lbs., at 2½ miles, which, at 150 lbs. the horse power, is equal to about six horses; but the machine was only designed to insure 4 horses' power, and to work upon a railway rising one in thirty-six.

To get rid of the cumbrous wheels and pistons, and avoid the jerks and concussions consequent upon Mr. Blenkinsop's arrangement, we find Mr. Ralph Dodd and Mr. George Stephenson taking out a joint patent "for various improvements in the construction of locomotive engines," which was dated Feb. 28, 1815. It consisted of the application of *a pin* upon one of the spokes of the running wheels that supported the engine; the lower end of the connecting rod being attached to the pin, and the upper end to the cross-head of

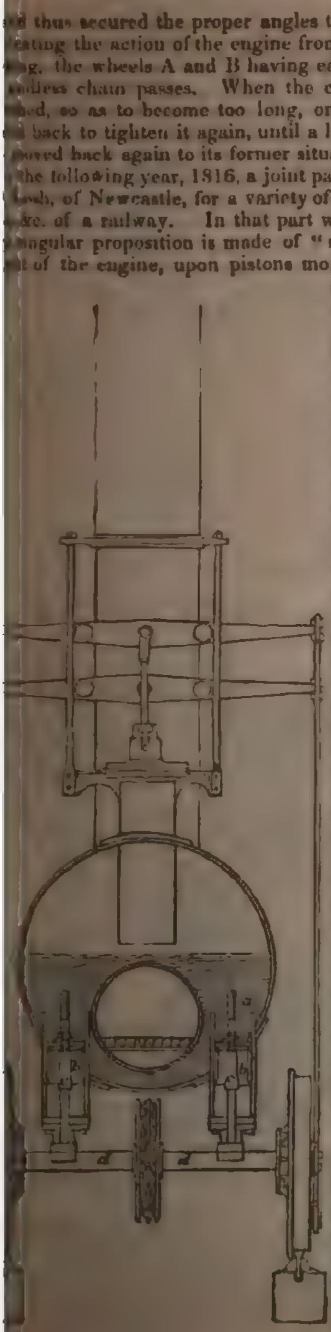
the piston rod, worked up and down by the piston. (The following engr serves to explain this invention, although it belongs to the patented imp ments subsequently introduced by Mr. Losh, in conjunction with Mr. Steve Mr. Dodd's previous invention being combined therein.) *a b* represents connecting-rod, the end *a* attached to the cross-head, and the end *b* to the spokes of the wheel; in like manner the end *d* of the other connecting is attached to the beam of the other piston, and the lower end to a pin fix the spokes of the wheel B. By these means the reciprocating motion of piston and connecting-rod is converted, by the pin upon the spokes acting crank, into a rotatory motion, and the continuation of this motion secure the one pin or crank being kept at right angles to the other as shown in drawing. To effect this, the patentees had two methods;—to crank the a on which each of the wheels were fixed, with a connecting-rod betwee keep them always at the angle with respect to each other; or to use a pec



sort of endless chain passing over a toothed wheel on each axle. This en chain consisted at first of one broad and two narrow links, alternately fas together at the ends with bolts; the two narrow links were always on the ou of the broad link; consequently, the distance they were separated laterally w be equal to the breadth of the broad link, which was generally about two inc and their length three inches. The periphery of the wheels fixed upon axles of the engine, was furnished with cogs, projecting from the rim o wheels (otherwise perfectly circular and flat) about an inch or an inch a half. When the wheel turned round, these projecting cogs entered bet the two narrow links, having a broad link between every two cogs, resti the rim of the wheel; these cogs, or projections, caused the chain to round with the wheel, and completely prevented it from slipping round the rim. When, therefore, this chain was laid upon the two toothed wh one wheel could not be moved round without the other moving round

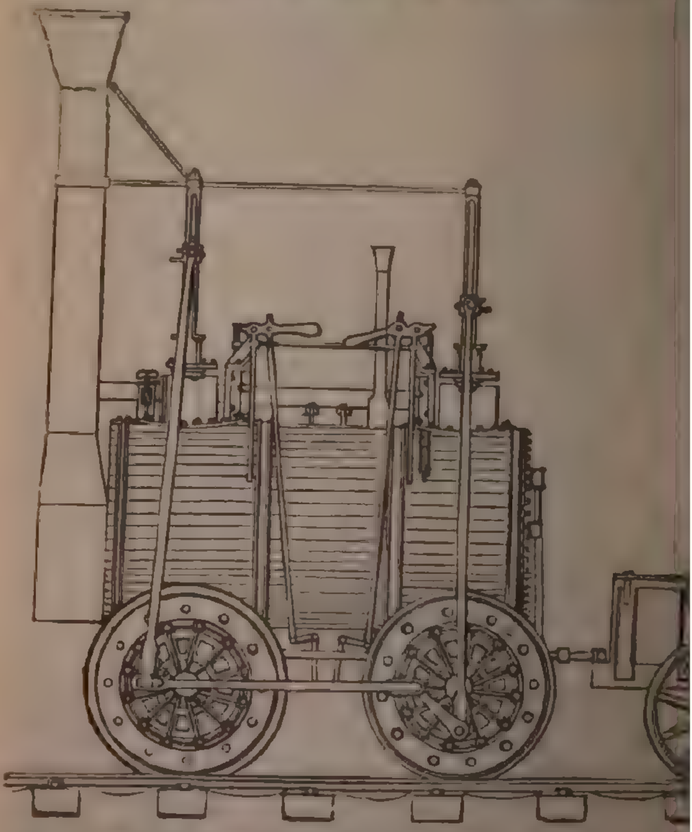
d thus secured the proper angles to the two cranks. This mode of com-
eating the action of the engine from one wheel to another, is shown in the
g. the wheels A and B having each projecting cog-wheels, round which
ndless chain passes. When the chain got worn by frequent use, or was
hed, so as to become too long, one of the chairs of the axles could be
back to tighten it again, until a link could be taken out, when the chair
oved back again to its former situation.

he following year, 1816, a joint patent was obtained by Messrs. Stevenson
osh, of Newcastle, for a variety of improvements in the carriages, wheels,
&c. of a railway. In that part which relates to locomotive engines, the
ngular proposition is made of "sustaining the weight or a part of the
t of the engine, upon pistons moveable within cylinders, into which the steam or water of the boiler is allowed to enter, in order to press upon such pistons; and which pistons are, by the intervention of levers and connecting-rods, made to bear upon the axles of the running wheels of the engine." The annexed section of a locomotive engine, exhibits the application of the "Steam-springs," as they were called. At *a a* are the steam-cylinders, containing the floating pistons *b b*, connected with rods, *c c*, the ends of which rest upon the brasses of the axles of the wheels *d d*. "These pistons, pressing equally on all the axles, cause each of the wheels to press with an equal stress upon the rails, and to act upon them with an equal degree of friction, although the rails should not all be in the same plane; for the bearing brasses have the liberty of moving in a perpendicular direction in a groove or slide, and carrying the axles and wheels along with them, free the wheels to accommodate themselves to the inequalties of the railway. The objects of these floating pistons are, to prevent the engine from receiving shocks, and preserve a steadiness of motion; the inventors considering, that by acting on an elastic fluid, they produce the desired effect "with much more accuracy than could be obtained by employing the finest springs of steel to support the engine." A longitudinal section of this locomotive engine is given in the preceding figure, in the description of Dodd and Stephenson's improvements, which it equally illustrates.



These locomotive engines were long in use at Killingsworth Colliery, near Newcastle, and at Hetton Colliery, on the Wear; so that their advantages and defects have been sufficiently submitted to the test of experiment. "The principal objections (in the opinion of Mr. Galloway), consist in the difficulty of surmounting even the slightest

ascent; for it has been found that a rise of only one-eighth of an i
a yard, or 18 feet in a mile, retards the speed of one of these engin
very great degree; so much so, indeed, that it has been considered n
in some parts where they are used, to aid their ascent with their
fixed engines, which drag them forward by means of ropes coiling
drum. The steam cylinders below the boiler were found very defective
the ascending stroke of the working piston, they were forced inw
the connecting-rod pulling at the wheel in turning it round, and in
scending stroke the same pistons were forced as much outwards: this
or play rendered it necessary to increase the length of the workin
der as much as there was play in the lower ones, to avoid the d
breaking or seriously injuring the top and bottom of the former by th
ing of the piston when it is forced too much up or down. As our
may not be fully comprehended without elucidation, let us imag
cylinder of a common beam engine to be set upon springs which hav
of one foot; the weight of the cylinder, when at rest, depresses the sp



inches; but if the engine be put in motion, then, as the piston
and gives motion to the machinery, the springs below the cylinder,
as it were, the abutments upon which the steam acts, are forced dow
against their seat with precisely the force that the piston exerts i
coming the resistance of the machinery. In like manner, when the

ends, as much weight or pressure will be taken off these springs by the e means: the cylinder would, therefore, vibrate or dance upon the bearing ngs; and as the motion which it thus obtains is the reverse of the motion given to the piston, the length of the cylinder should be greater to allow the extreme vibration to which it is liable. A quantity of steam would, refore, be lost in filling up this extra length of the cylinder at each stroke. s would also happen if the cylinder were *fixed*, as usual, and the carriages the crank and fly-wheel supported upon springs; and this arrangement uld then be exactly the same, in principle and effect, as the parts of the omotive engine to which we now allude."

The engraving on the preceding page represents one of the engines made the Kirkintilloch and Monkland Colliery Railway, by Messrs. Murdoch and ken of Glasgow. The working of these engines gave, it is said, very high satis- tion to the proprietors, as performing more work than the engineers undertook y should execute. As there appears to be nothing in the arrangement of the ts which was not previously known, we can only attribute the high character he engines attained, to superior workmanship—and the clothing of the engine a wooden casing, to prevent the waste of heat. It affords a good example of old fashioned locomotives, and shows a peculiar mode of coupling the eels. The connecting rod between the two wheels has a ball and socket joint each end, making universal joints. The wheels have a play of about e inch to allow for turning in the sharp curves of the line. The cylinders 10½ inches diameter each, and the stroke two feet, pressure of steam 50lbs. e average speed of these engines was 6 miles per hour, which is quite ade- ate for the purposes of a colliery. They were the first locomotive engines de in *Glasgow*.

The improvements in the engine or carriage wheels proposed by Messrs. phenson and Losh, in their patent of 1816, consisted in forming the spokes malleable iron, and uniting them in the sand by casting the ring and nave to m. In some cases, they made the "spokes of cast iron, with hoops, tires, or ds of malleable iron."

Fig. 1 is a side view of the wheels, with wrought-iron arms. *a a a* show the s cast in the nave, and dropped into mortice holes made in the rim, which

Fig. 2. *Fig.* 1. *Fig.* 3.

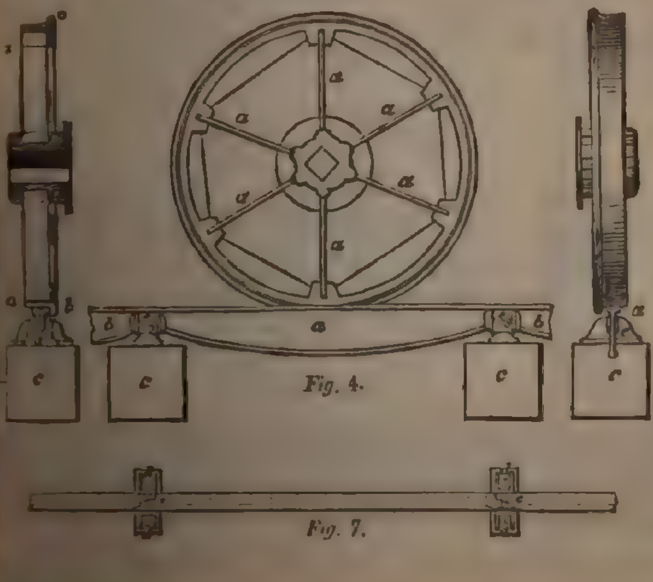


Fig. 4.

Fig. 6.

Fig. 7.

are dovetailed, to suit the dovetailed ends of the arms *a a a*. The arms are heated red hot previous to dropping them into the holes, in order to cause them to extend sufficiently for that purpose, for when cold they are too short, owing to the property which iron possesses, of expanding on the application of heat, and of contracting again to its former dimensions on cooling down to the same temperature from which it was raised; the arms, therefore, on cooling, are drawn with a force sufficient to produce a degree of combination between their dovetailed ends and the mortices of the rim, which prevents the possibility of their working loose; they are afterwards keyed up; the mortice holes are also dovetailed, from the tail side of the wheel (*a a*, *Fig.* 2.) to the crease side (*b* in the same figure).

Fig. 2 is a cross section through the centre of the wheel, with wrought-iron arms.

Fig. 3 is an end view of *Fig.* 2.

Fig. 4 represents an elevation of the edge railway, showing a rail *a* connected with the two adjoining rails, the ends of which are shown by *b b*, and resting in the props or pedestals, the bases of which are the metal chairs that are bolted to the stone supports *c c*. The joints *e e* are made by the ends of the rails being applied to each other by what is termed a half lap; and the pin or bolt *g* which fixes them to each other, and to the chair in which they are inserted, is made to fit exactly a hole which is drilled through the chair and both ends of the rails, at such a height as to allow both ends of the rails to bear on the chair, and the bearance being the apex of a curve, they both bear at the same point. Thus the end of one rail cannot rise above that of the adjoining one; for although the chair may move on the pin in the direction of the line of the road, yet the rails will still rest upon the curved surface of their bearance without moving.

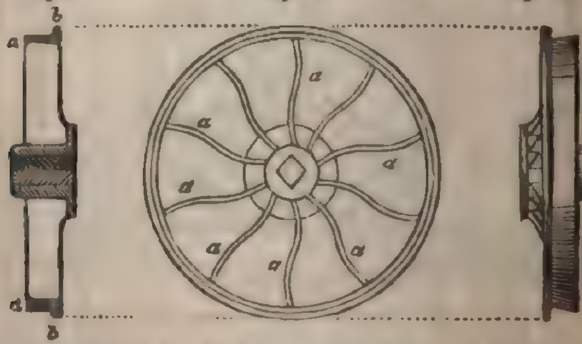
Fig. 5 is a cross section of our edge-railway through the middle of one of the chairs *a*, and across the ends of the two adjoining rails, which are connected by a transverse pin; *c* is the stone support or sleeper.

Fig. 6 is a cross section of the rail *a*, at the centre, and shows the supports at the farther extremity.

Fig. 7 is a plan of the railway described at *Fig.* 1, showing the half-lap joinings of the rails *e e* placed in their carriages *d d.*

Fig. 8, in the subjoined cut, is a view of the cast-iron wheel with the malleable iron tire. This wheel is made with curved spokes, as shown at *a a a*, and with a slit or aperture in the rim, shown at *b*, into which a key is inserted. The reason of this is, that on the application of the hot tire, the cast metal

Fig. 9. *Fig.* 8. *Fig.* 10.



expands unequally, and the rim is liable to be cracked, and the rims drawn off, unless the first is previously slit or opened, and the latter curved, which allow them to accommodate themselves to the increased diameter of the wheel; by this formation of the wheel, the tire may be placed on when cold, and keyed up afterwards.

Fig. 9 is a cross section of *Fig.* 8, through the centre. *a a* show the tire; *b b* the metal rim. This cast metal rim is dovetailed; so that when the tire, which is dovetailed to suit it, is put on hot, it contracts, and applies itself to the rim with a degree of adhesion which prevents its coming off from the motion of the wheel on the railway. This wheel is of the form to suit an edge-railway; and to make it answer for a plate-rail, it only requires the rim to be flat.

Fig. 10 is an end view of *Fig.* 8 without the malleable iron tire.

The same patent comprises improvements in "rolleys" or tram-wheels, and in tram-plates. The first consists in the combination of cast and wrought-iron, after the same method as already described with respect to the larger or edge-rail wheels; and the second consists in some judicious modes of fixing the ram-plates to the chairs, through the means of tenons and mortices, so that the ends of the rails are kept firmly in their places.

The transit of coals from the mines to the place of shipment added so much to their cost, that the owners were naturally solicitous to adopt any improvement calculated to lessen it. And the great ameliorations introduced by Messrs. Losh and Stephenson, just described, were of so decided a character, as to become very generally preferred in the collieries of the north; where they continued in use for many years. There was, however, an unquestionable defect in the material used. Cast-iron, although it offers great facilities in producing the desired shapes to resist strains; to economise metal in those parts where much strength is not required; and to afford the most convenient adaptations in fitting together, can never be entirely depended upon, until certain and easily practised means shall be discovered of expelling the air contained in the moulds. From the casting's being often *blown* in invisible places, frequent breakages were unavoidable, from this cause alone; to which may be added, the derangements of the substructure of the line, which, however well executed, is always taking place in different parts, according as they may be subjected to the various disturbing causes; such as wet, friction, concussions, &c., altogether producing, in extensive lines, a very serious amount of breakage, and a heavy expense for repairs; nevertheless, previous to Messrs. Losh and Stephenson, the expense of repairs was much greater.

Although the rails in general use were for the most part of cast iron, there were some of malleable iron, made of the ordinary rectangular figure by rolling; which latter were liable to be rendered unserviceable by becoming bent. To remedy this defect in the malleable, and the liability to break in the cast iron, Mr. John Hawks, of Gateshead, Durham, took out a patent in the year 1817, "for a new method of making rails," in which the metal in both its states was combined. The specification states, "Instead of making the rails or bars of cast or malleable iron, as those now in use are, they are a compound of malleable and cast iron, so connected as to be stronger than if made of either kind alone. The surface is formed of cast iron, and the back, or under part, of malleable iron, joined together and formed when the metal of the former is in a fluid state; and they become so inseparable that the cast iron may be broken at the nearest possible distances; indeed, even inch by inch, which is scarcely possible to be occasioned by accident, and the rail will remain sufficient for the purposes of a railway; at least, till it suits the convenience of the workmen to replace it, without interruption to the concern in which the railway may be used: and as a loss by a broken rail of this invention will be less than one in common use, the expense, although it may be a little more in the first instance, will be considerably less in the end, as the malleable iron may be used again, or as the old iron will be of much more intrinsic value than the other."

The modes of combining cast and malleable iron together in the rails are various; but that which Mr. Hawks preferred as affording the best security for their being firmly fixed together, is by running the cast iron, when in a state of fusion, on the malleable iron; to effect which the malleable part is to be first forged, or otherwise prepared in that form and of that strength which the nature of its intended purpose or appropriation points out as most proper. That part of the malleable iron which is intended to be combined with the cast iron

should be rendered rough and uneven by jagging or by perforation, by giving a dovetailed form, or by any other means, so that the cast iron may firm adhere thereto, without the liability of becoming loose by the violent action of the carriages. The malleable part must be clean, perfectly dry and warm, whe laid in the mould to receive the melted iron, which should be poured in as soo as possible after the mould is ready to receive it, as any damp on the malleab iron will endanger the soundness of the cast iron part.

It is a remarkable fact in the history of our iron manufacture, that at advanced a period as 1817 no attempt had been made to make railway bars of malleable iron of a judicious form, like those used in the cast metal. It woul seem that the manufacturers of that time imagined that their grandfathers ha taught them all that it was possible to acquire in their art of rolling bars; tha it was too wild an attempt to make any other form than cylindrical and rectan gular, although they might obviously effect the required configuration by th same tools and machinery, with merely a slight deviation in the form of th grooves. In consequence the proprietors of the railways and coal-works wen on breaking their cast iron and bending their weakly shaped malleable bar incurring for three years afterwards very serious accidents and loss. At lengt Mr. John Birkenshaw, of Bedlington, made the notable discovery we have ju alluded to, (and which we should have thought would have been obvious everybody,) of making the grooves of the shape desired. He took out a pate for his invention in 1820, and made, it is said, a considerable fortune by it his specification we will now make an extract from :—

"My invention consists in the adaptation of wrought or malleable iron ba or rails of a peculiar form, instead of cast iron rails, as heretofore. From th brittle nature of cast iron, it has been found, by experience, necessary to mak the bars of a railroad sufficiently strong to bear at least six times the weig intended to be carried along the road, by which the original cost of a railw was considerably augmented; or if light rails were used, the necessity of fre quently repairing entailed a very heavy expense upon the proprietors. To obvia these objections, I have invented a bar to be made of wrought, or mallea iron, the original cost of which will be less than the ordinary cast iron rails bars, and, at the same time, will be found to require little (if any) reparation the course of many years. The rails or bars which I have invented are forme as prisms, though their sides need not of necessity be flat. *Figs.* 1 and 2 sho

Fig. 1.

Fig. 2.

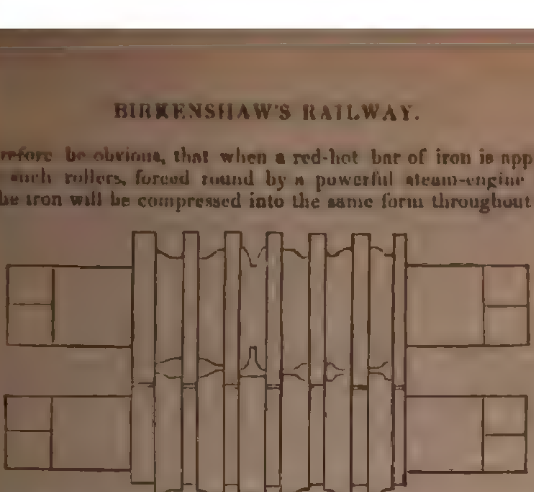
Fig. 3.

Fig. 4.

sections of the bar thus formed; the upper surface upon which the wheel the carriage is to run is slightly convex, in order to reduce the friction, a the under part rests in the supporting-blocks, chairs, rests, standards pedestals, which are mounted upon the sleepers. The wedge-form is prope because the strength of the rail is always in proportion to the square of breadth and depth. Hence this form possesses all the strength of a cube eq to its square, with only half the quantity of metal, and, consequently, half cost. Sufficient strength, however, may be still retained, and the weight metal further reduced, by forming the bars with concave sides, as shown section, by *Figs.* 3 and 4."

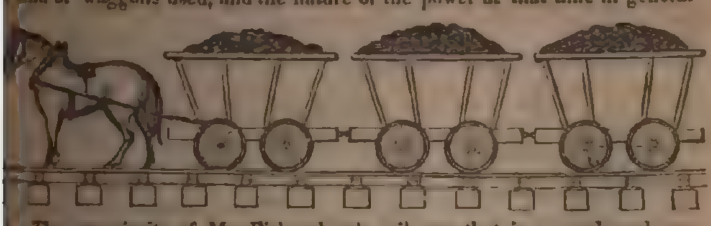
The rolls made use of by Mr. Birkenshaw are exhibited in the anne figure, which represents an elevation or side view of a pair of them. It be observed that the circumference of each roll is indented by a series grooves; each groove in the upper roll corresponding in shape with those the lower roll, excepting in one case. Consequently the figures described the hollow spaces between each roll, represent the form of the bars to be ma

therefore be obvious, that when a red-hot bar of iron is applied to the of such rollers, forced round by a powerful steam-engine with great ity, the iron will be compressed into the same form throughout its length.



form of rail now most approved of, which we shall have occasion hereafter cribe, is made by the same kind of machinery.

e annexed wood engraving is designed to show Mr. Birkenshaw's railway, ind of waggons used, and the nature of the power at that time in general



The superiority of Mr. Birkenshaw's rail over that in general used pre-ly, which was the joint invention of Messrs. Stephenson and Losh, excited rivalry of the latter gentleman; accordingly we find him taking out another t for "certain improvements in the construction of iron rails for railroads," h being to us very doubtful, we shall describe it very briefly in his own —"First, in using, placing, and fixing bars of malleable iron on the surface of a line of cast iron rails or malleable iron rails, of whatever such rails may be in the longitudinal direction of the rails when laid, so form an uninterrupted line the whole length of the bar, which may be as as it shall be found convenient and economical to use, and of the same th as the upper surface of the rails to which it is fixed, or a little broader rrower. Secondly, in some cases I fix a band or strap of malleable iron under surface of rails made of cast iron, in order that such band or strap by its power of tension, give support to the cohesion of the parts of the iron rails, and admit of its being made lighter, and thus save expense, while to security from breakage. Thirdly, I claim as an improvement, a rail d by fixing two bars of malleable iron on their sides or edges, and fixing in that position by bolts and studs, or by any other convenient method; their upper edges placing and fixing a flat bar of malleable iron, or one n slightly curved or rounded at the edges to diminish friction, so that or plate, placed and fixed on the upper edges of the two malleable iron shall form the surface upon which the wheels of the waggon or carriage revolve." After this statement, we think the practical reader will not appointed if we omit the details of construction.

new species of railway, possessing many advantages peculiar to itself, was ed and patented in the year 1821 by the late Mr. H. R. Palmer, who was ne years engineer to the London Dock Company. Instead of two lines laid upon the ground, as heretofore, Mr. Palmer's railway consists of ne, which is elevated upon pillars, and carried in a straight line across untry, however undulating and rugged, over hills, valleys, brooks, and

rivers, the pillars being longer or shorter, to suit the height of the rail above the surface of the ground, so as to preserve the line of the rail *always straight*, whether the plane be horizontal or inclined. The waggons, or receptacles for the goods, travel in pairs, one of a pair being suspended on one side of the rail,

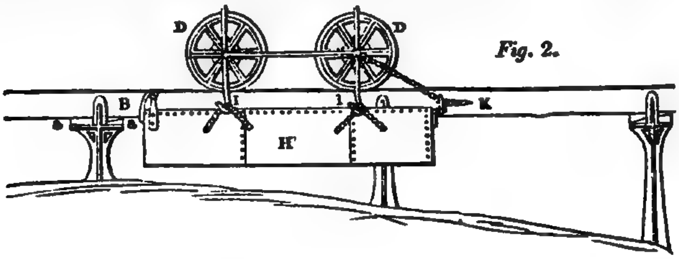


Fig. 2.

Fig. 1.

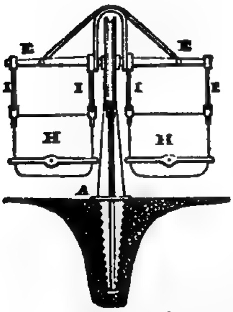
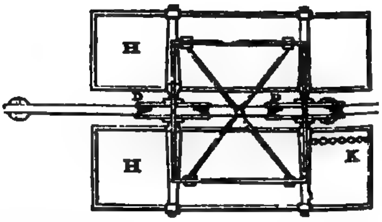


Fig. 3.



and the other on the opposite side, like panniers from the back of a horse. By this arrangement only two wheels are employed, instead of eight, to convey a pair of waggons; these two wheels are placed one before the other on the rail, and the axle-trees upon which they revolve are made of sufficient length and strength to form extended arms of support, to which are suspended the waggons or receptacles on each side of the rail, *the centre of gravity being always below the surface of the rail.* The rods by which the waggons are suspended are inflexible; hence, although the weights on each side be not equal, they will, nevertheless, be in equilibrio; as may be observed in a ship, which, being unequally loaded, assumes such an angle with the surface as preserves the equilibrium. Although an equal distribution of the load on both sides is desirable, it is not necessary. A number of carriages are linked together, and towed along the rail by a horse, as barges on a canal. Owing to the undulation of the country, the horse will sometimes be much below the rail, in consequence of which he is provided with a sufficient length of rope to preserve a proper angle of draught.

Fig. 1 is an end view of the carriage, with a cross section of the rail, and a pillar, showing its form, and manner of fixing.

Fig. 2 is a side view of the railway passing over an uneven surface, with three of the supporting pillars of unequal length. Upon the upper surface of the rail are seen the two carriage-wheels, and the manner of suspending the waggons or receptacles from the axle-trees, which is, however, better shown by *Fig.* 1, letters I I I I.

Fig. 3 is a plan of the same, which exhibits the comparative measurements, and the mode by which the receptacles are braced together. The same letters of reference refer to the same parts in the different figures. A, *Fig.* 1, represents an upright pillar of cast iron, having, at the shoulder, a flange, which rests upon the surface of the ground. The pillar is formed with ribs at right angles,

converge towards the lower extremity, and are notched in the edges, for better securing it firmly in the ground. The hole in which it is to be inserted be previously well rammed, by a kind of pile-driving engine, and the foot pillar surrounded with hard materials, which are also to be rendered compact as possible. Three of these pillars are shown fixed in *Fig.* 2, placed nine feet apart. At the upper extremities of the pillars are long clefts or ngs, to receive the rail B, which is composed of deal planks, set on their with their upper surface D defended by cast or wrought iron plates, a convex on the upper side. When the rail has been some time in use, and taken a bearing, a little adjustment of the line may be requisite before ail is bolted to the pillars; to effect which, a very simple and easy method vided. In the cleft of the pillars, and under the rail, two wedges *a a* are ced in opposite directions, whereby its level may be adjusted with the accuracy. The wheels D D are provided with flanges, to keep them on il, and their peripheries are slightly concave, to adapt their surfaces to that rails. E E are the arms or axles; H H are the receptacles for the which are made of plate iron, and are suspended to the arms, as before oned, by the inflexible rods I I I I. To one of the arms a chain K is d, to which a towing-rope may be connected. Any number of carriages hen be attached together by chains hooked on to the angles.

e annexed *Fig.* 4 is intended to exhibit a portion of the railway in use, the methods by which several of the obstacles which frequently present elves are overcome. On the left is seen a jointed rail, or gate, that crosses d over which the carriages have just passed, and the gate swung back, the road open; the horse and man having just forded, the train of car- is proceeding in its course, and following another train, part of which is on the right, crossing a rail bridge, simply constructed for that purpose. vision is made for trains of carriages that are proceeding in opposite tions, by means of "sidings" or passing places. With respect to loading, receptacles be not loaded at the same time, that which is loaded first be supported until the second is full. Where there is a permanent loading- the carriage is brought over a step or block; but when it is loaded pro- ously, it is provided with a support connected to it, which is turned up

Fig. 4.

t in use. From the small height of the carriage, the loading of those ually done by hand becomes less laborious. The unloading may be various ways, according to the substance to be discharged, the recep- ing made to open either at the bottom, the ends, or the sides. In some may be desirable to suspend them by their ends, when, turning on their ntres, they are easily discharged sideways.

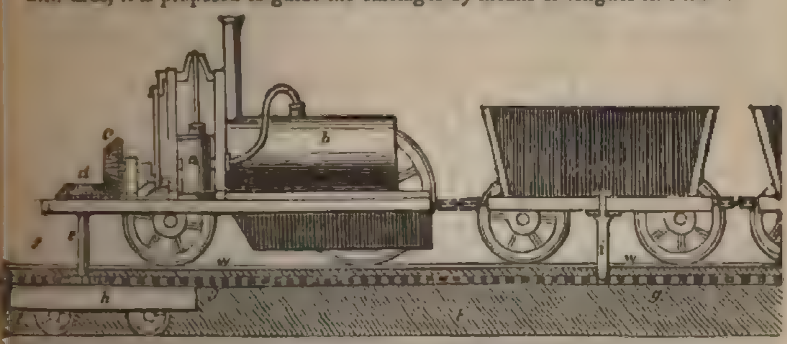
Among the advantages contemplated by the patentee of this railway, may be mentioned that of enabling the engineer, in most cases, to construct a railway on that plane which is most effectual, and where the shape of the country would occasion too great an expenditure on former plans—that of being maintained in a perfectly straight line, and in the facility with which it may always be adjusted; in being unencumbered with extraneous substances lying upon it; in receiving no interruption from snow, as the little that may lodge on the rail is cleared off by merely fixing a brush before the first carriage in the train; in the facility with which the loads may be transferred from the railway on to the carriages, by merely unhooking the receptacles, without displacing the goods, or from other carriages to the railway, by the reverse operation; in the preservation of the articles conveyed from being fractured, owing to the more uniform gliding motion of the carriages; in occupying less land than any other railway; in requiring no levelling or road-making; in adapting itself to all situations, as it may be constructed on the side of any public road, on the waste and irregular margins, on the beach or shingles of the sea-shore,—indeed where no other road can be made; in the original cost being much less and the impediments and great expense occasioned by repairs in the ordinary mode being in this method almost avoided.

A line of railway on this principle was erected, in 1825, at Cheshunt, in Hertfordshire, chiefly for conveying bricks from that town, across the marshes, for shipment in the river Lea. The posts which support the rails are about ten feet apart, and vary in their height from two to five feet, according to the undulations of the surface, and so as to preserve a continuous horizontal line to the rail. The posts were made of sound pieces of old oak, ship timber, and in the slots or clefts at the upper ends of the posts, are fixed deal planks twelve inches by three, set in edgeways, and covering with a thin bar of iron, about four inches wide, flat on its under side, and very slightly rounded on its upper side; the true plane of the rail being regulated or preserved by the action of counter wedges between the bottom of the mortices, and that of the planks. By this rail, on the level, one horse seemed to be capable of drawing at the usual pace about fourteen tons, including the carriages.

The next invention in the order of time that presents itself to our notice, is one possessing considerable originality; and though it has not been carried into effect, it contains some ingenious suggestions, that have formed the groundwork of subsequent inventions. It is the subject of a patent granted to William Francis Snowden, of Oxford-street, London, on the 18th of December, 1824, for a "new invented wheel-way and its carriages for the conveyance of passengers, merchandise, and other things, along roads, rails, and other ways, either on a level or inclined plane."

The specification describes the invention under two distinct heads; the first, which is the most practical of the two, is explained as consisting of a hollow trunk with a platform of iron on the top for waggons or other carriages to run upon; inside the trunk is placed a machine, called by the patentee a mechanical horse, to which is connected a toothed wheel, that is made to revolve in a horizontal plane, and to take into the teeth of a horizontal straight rack fixed on one side of the hollow trunk. The vertical axis of the horizontal toothed wheel passes through a longitudinal opening in the wheel-way; above which it is connected to a locomotive steam-engine, and is actuated thereby; through the medium of bevil gear the motion thus communicated to the latter by the engine is applied by the vertical axis to the horizontal wheel of the mechanical horse inside the hollow trunk; and as the horizontal wheel is geared into the toothed rack, which is *fixed* on one side of the trunk, the mechanical horse of necessity moves forward with the same velocity as the horizontal wheel is made to revolve by the power of the engine. This will be understood upon reference to the annexed figure, which affords a longitudinal section of the mechanical horse and the hollow trunk or wheel-way. *a* is a vibrating cylinder, and *b* the boiler of a locomotive engine, by which the bevil gear *c d* is actuated, and through the medium of the vertical axis *e*, the horizontal toothed wheel *f* which takes into a toothed rack *g*; the mechanical horse *h* is made to advance in its course

and to take with it the engine and the train of waggons that may be in connexion. *w w* is the wheel-way, and *t t* the hollow trunk. As the top of the wheel-way is supposed to be flat, and the carriages without lateral flanges to their tires, it is proposed to guide the carriages by means of tongues like that at

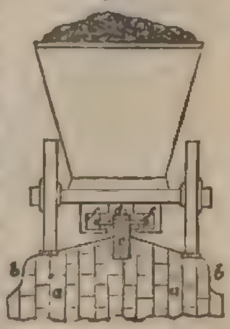


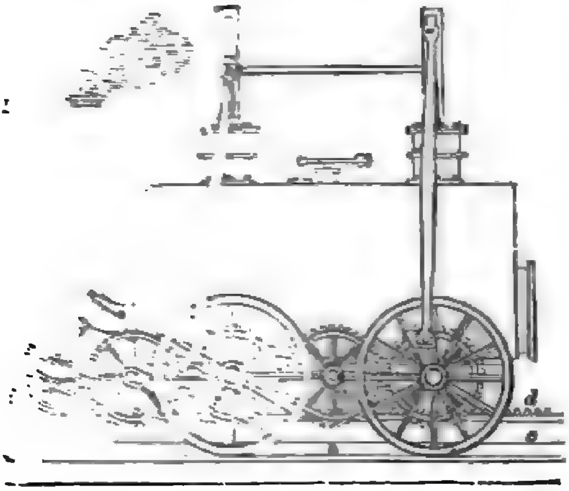
i, which enters the longitudinal apeture, and which may be provided with an antifriction roller to prevent lateral rubbing. The inventor proposes to adopt a similar arrangement to the foregoing for the towing of barges, by erecting his patent wheel-ways by the sides or banks of canals and rivers.

In the preceding pages are given some plans for the employment of toothed racks to railways, to enable a carriage, provided with a toothed wheel, taking into the teeth of the rack, to obtain sufficient resistance to ascend steep inclined planes: but the former were subject to the disadvantage of a strain or twist, the rack in them being placed on one *side* of the way. To obviate this defect appears to have been the object of Mr. Josiah Easton, who took out a patent, dated the 13th October, 1825, for "certain improvements in locomotive or steam carriages, and also in the manner of constructing the roads or ways for the same to travel on." The following brief description of this invention is given in the *London Journal of Arts*, Vol. XI.:—"These improvements consist, first, in forming a line of road, with a raised part along the middle, upon which a rack, or toothed bar of iron is placed; and secondly, in adapting a toothed wheel to the steam carriage, which shall take into the said rack, and being actuated by the rotatory power of the steam-engine, shall thereby cause the carriage to be impelled forward upon the line of railroad, and the trams or other waggons after it."

In the subjoined cuts, *Fig.* 1 exhibits a transverse section of the railroad, with the end view of a waggon upon it. *Fig.* 2 is a side elevation of the same, showing the manner in which the carriage is driven; *a a* is the road formed of masonry, the parts *b b*, on which the running wheels travel, being on a lower plane than the central part of the road, whereon the rack *d* is situated. The steam-engine, and other machinery appertaining to the locomotive, are constructed in the usual way; the only novelty in the carriage is the toothed wheel *e*, which takes into the rack *d*, fixed along the centre of the road; and this toothed wheel being made to turn through the agency of a train of wheels actuated by the steam-engine, the carriage is thereby propelled, and the waggons drawn after it. In order to keep the carriages in their track upon the road, two guide rollers *f f* are placed under the carriage, which run against the side of the central rib, and this prevents them from moving out of their course.

Fig. 1.





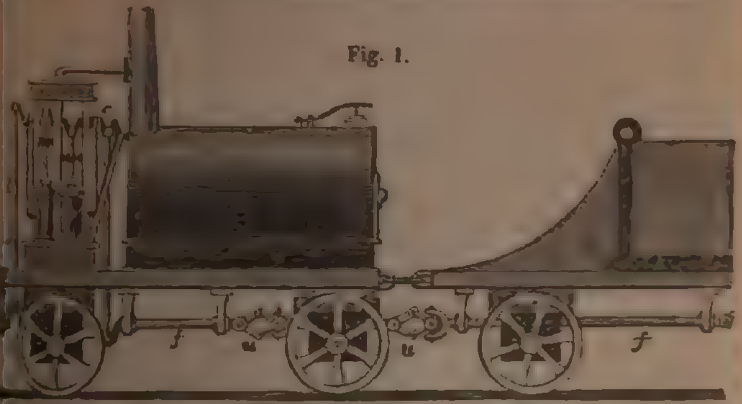
[illegible] steeper inclined planes than had [illegible] and likewise to enable the carriages and [illegible] without the severe friction and strain- [illegible] was the object of a patent [illegible] Mr. W. Henry James, of Birmingham. [illegible] carried into effect on the great scale; [illegible] the most satisfactory proofs have been [illegible] repeated trials on a railroad more than a [illegible] for the purpose of experiment, on which it [illegible] inclined planes three inches in [illegible] This important advantage is [illegible] the wheels of the several car- [illegible] a long horizontal rod (or series [illegible] under each carriage.

[illegible] proposed by Mr. James for enabling the [illegible] curves in the road, without addi- [illegible] rotatory shafts, which cause [illegible] propel the carriages forward, are [illegible] which communicates the [illegible] even if so placed on the curves of [illegible] present to the side of the next an- [illegible] degrees. To cause the carriage wheels to run round the curves [illegible] rubbing of their surfaces, the rails [illegible] elevations, and the wheels of the [illegible] correspond with those ribs, by their peri- [illegible] manner; so that a wheel, in effect, possesses as [illegible] as there are variations in the surface of its periphery, by which [illegible] may be made to travel faster or slower, as may be desired.

The following engravings will render these plans intelligible to the reader. [illegible] the boiler of a steam-engine, [illegible] the engine with two cylinders, the alter- [illegible] motion of the piston in which gives rotation to the crank c above: the [illegible] e e, attached to the same, being also fixed to the crank of the horizontal shaft [illegible] which passes under the carriages, causes that to revolve with a similar speed to the crank of the engine. Two square boxes, g g, are fixed under each carriage: through these the axletrees of each pair of wheels pass; the rotatory shaft f passes also through the boxes above the axletrees, and at right angles with them: each of the boxes g g contains a double-beveled horizontal wheel

which presents a circle of cogs in its upper as well as its lower side, and turns [illegible] cross bearings: now the shaft f carrying upon it a vertical beveled pinion in each box, takes into the upper circle of teeth of the horizontal wheel, while the under circle of the teeth of the same actuate a beveled pinion on the axle-tree underneath, consequently compelling the wheels to revolve; and the power being thus applied to every pair of wheels simultaneously, sufficient resistance is obtained, on a smooth surface, to ascend inclined planes of considerable elevation. u u u u are the universal joints, which communicate rotatory motion

Fig. 1.



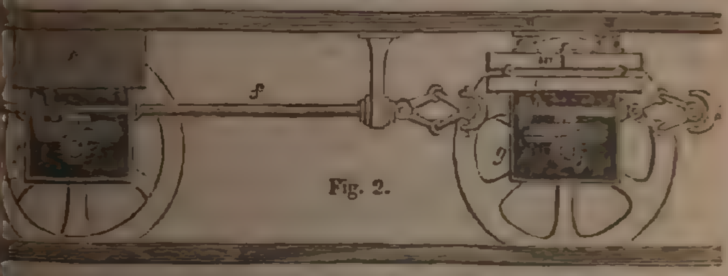


Fig. 2.

when the carriages are not in a straight line; these, and other moving parts, are clearly shown in *Fig.* 2, which is upon a larger scale. f f is the rotatory shaft; g g the two boxes, with the front plates moved, to show the gear inside; h h the beveled pinions upon the shaft in each box; i i the horizontal double-cogged wheels. The front box g, under the carriage, is fixed immovably to a solid block of wood, k; the other box is fitted to a plate l, turning on a central pin, which passes through another plate m, above, the latter being secured to the floor of the carriage by hinge-joints, n n. The construction of the universal joints u u is also more clearly shown in this figure.

We have now to describe the contrivances by which the patentee proposes to obviate the destructive effects of the rubbing or sliding of the inner wheels of carriages in making curves or turns in a round. If the wheels on one side of a carriage be larger, or of greater diameter than those on the opposite side, such carriage, when propelled, will necessarily make a curve. On this principle the patentee's contrivances are founded. In running along a straight line, the peripheries of the wheels are of equal elevation; but when the carriage has to make a turn, the wheels on one side roll on a greater diameter, or more extended periphery, while the wheels on the opposite side run on a less extended periphery, and the elevations upon the rails on which they run are so adjusted to the variations, that the different peripheries of the wheels change and come

in contact with the variable parts of the rail, and run round the curves without any increase of friction.

A patent for a suspension railway was granted to Mr. J. G. Fisher, on the 2d of April, 1825. This gentleman, it will be observed, suspends his carriages to a double line of rail; in this respect, however, he was anticipated in idea by Mr. Palmer, who, in his little interesting book, entitled, *Description of a Railway upon a New Principle*, observes,—"to elevate two lines of rail for the purpose of supporting a carriage, could not be done at a sufficiently moderate expense; I therefore endeavoured to arrange the form of a carriage in such a manner that it would travel upon a single line of rail without the possibility of overturning." Nevertheless, if an inventor can succeed in carrying into beneficial operation that which was thought of by another as ineligible to attempt, he is entitled to respectful consideration.

Mr. Fisher's plan is, however, not without originality, and, with some modifications, may be rendered useful in many situations. The chief object is stated to be the throwing of a railroad across rivers, swamps, &c.; and the means proposed of effecting it will be readily perceived upon inspecting the following diagrams, and referring to the subjoined explanation of them.

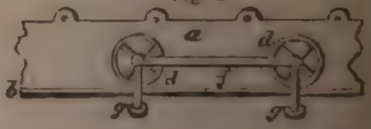
Fig. 1 is a side view of the proposed rail, attached by vertical rods to a chain of bars, which form a catenarian curve; *Fig.* 2 is a similar view, but giving only a portion of *Fig.* 1 on a larger scale; *Fig.* 3 is an end or sectional view of *Fig.* 2; *Fig.* 4 is also a sectional view, but of another form of rail, which we shall describe lastly. The letters of reference denote similar parts in each of the figures. *a* is the rail, made of stout cast-iron plates, of uniform dimensions, bolted together, having a horizontal projection, or plate, *b b*, on each side, for the wheels of the carriages, *d d*, to run upon (seen best in *Fig.* 3). *f f* shows the frame of the carriage: the manner of constructing the wheels on either side of the rail, in pairs, is exhibited in *Fig.* 3, and the mode of joining the front with the hind pair of wheels, in *Fig.* 2. Iron rings, *g g*, pass through the centres of the lower parts of the carriage-frame, to which are suspended the boxes or

Fig. 1.

Fig. 4.

Fig. 3.

Fig. 2.



receptacles for holding the goods or passengers, one of which is shown attached at *h*, *Fig.* 1. The loops or holes in the upper part of the rail *a*, *Fig.* 2, are, of course, for the convenience of bolting it to the suspension bars, as seen connected in *Fig.* 1. Each of the bars is to be provided with a wedge or screw of adjustment, so as to regulate the uniformity of the plane when any part sinks. To give an idea of the other form of rail, the section *Fig.* 4 is sufficient. Here it will be seen that the rail (if we may so term it) is of the form of a square tube or hollow trunk, *i i*, with an opening or slit on the lower side for the bar (which is fixed to the axletree of the carriage) to pass through, for the purpose of being connected to a box or receptacle underneath. This square cast-iron trunk, or rail, is to be suspended, as in the previously described rail, to a chain of iron bars or wires, drawn nearly tight, so as to form a catenarian curve or stretched over the place to be crossed.

le of propelling the carriages is, we believe, not stated in the specifi- we understand it is to be performed, when the crossing of rivers or he object, by elevating that end in which the carriages are placed, them find their way to the other end by their own gravity. By osition, it is probable that the patentee does not intend it for any ork, as the means proposed of producing motion are applicable only as we have mentioned.

ndispensable that carriages which have to run upon edge railways ovided with wheels that have lateral flanges upon their peripheries them from running off it; and as such projecting flanges render icable to carriages on the common road, into which they would destructive incisions, if drawn or propelled over them, it necessarily mportance to contrive such a wheel, or periphery of a wheel, as ithout detriment on either road or rail. We think we have noticed hods of providing for this object: but that which appertains to our onological position is the subject of a patent granted to R. W. Esq., of Newcastle-upon-Tyne, on the 12th of April, 1825. The ses for this purpose have tires, provided, as it were, with two peri- xternal circles of different diameters. Thus, upon an edge rail, the the smaller diameter of the tire runs upon it, and the larger diameter guiding flange to keep the carriage in its course. And when the n upon a common road, the larger diameter only comes into opera- g the smaller diameter clear of the ground, unless the latter should state, when it will tend to keep the wheel from sinking deeper in the patentee has likewise included in his specification some plans for ns or curves in the roads, by means of projecting ribs on the surface of different elevations, with wheels designed to correspond thereto, ese contrivances Mr. Brandling was anticipated a few weeks prior H. James (already described), we shall not here enlarge on the

vention patented by Mr. Thomas Hill, Jun., of Ashton-under-Line, 10th of May, 1825, that gentleman proposes to construct a steam- ally adapted to run upon edge-rails, tram-plates, and the common this purpose he makes the guiding flanges removable at pleasure by val of bolts, by which they are connected to the fellies of the wheels. vention consists in making the running wheels of the carriage revolve a fixed axletree, which, when applied to railways, he considers to d useful invention. This is, however, a mistake, as they have been were abandoned on account of their unsteadiness, and other defec- A third contrivance is to lock the fore-axle to the perch, to prevent round when upon a Railway, by means of a square staple entering s. A fourth invention consists in making the rails of tubes instead s, to save metal, and obtain strength. There are some other trifling or alterations to steam-carriages and railroads, for the description of must refer the reader, who may require more information, to the cument.

sion railway, combining the characteristic features of Mr. Palmer's ber's previously described, was patented by Mr. Maxwell Dick, of Ayrshire, on the 21st of May, 1829; doubtless, in ignorance of those as we were personally assured by the latter patentee. The chief his gentleman was, as is stated in the title of his patent, "for the of passengers, letters, intelligence, packages, and other goods, with y. The means which he adopts for this purpose, are designed to necessity and enormous expense of cutting and embanking resorted ys of the ordinary kind. The rail is supported, like Mr. Palmer's, al pillars, but carrying a double track for the carriages, like Mr. Mr. Dick has, however, added, what he denominates "safety rails," side of the track, against which anti-friction wheels, attached to s, are made to act, in case of the carriages receiving from any pulse upwards. The patent likewise embraces a combination of

wheel-work, for communicating a high velocity to the carriages. A large and well constructed working model of this invention was publicly exhibited for several weeks at Charing Cross, London, in 1830, and drew crowds of visitors, who were surprised and delighted at the velocity with which the carriages darted along the wire rails across the room, by the application of a small force. The notoriety of this invention, as well as the capability of its being usefully applied under many circumstances and situations, for light loads at high velocities, seems to require from us something more than this brief historical notice. Accordingly we proceed to give a few, out of the many details and modifications, which the prolific mind of the inventor has thrown together in his specification. From this document we learn that the patentee especially designed his invention for traversing undulating, rugged, and abrupt ground, the crossing of rivers, mosses, marshes, &c. Pillars are to be erected of brick or stone with lime, at given distances apart, suppose fifty yards; between each of these may be placed four or five cast metal pillars, according to circumstances, for bestowing the requisite stability and keeping the rail free from undulations. On the top of each of the pillars is to be fastened a frame, to which the rails are to be secured, and to the frames are connected grooved friction wheels or pulleys, between which the drag-line is conducted. The rails are to be made of the best wrought iron, such as is used for chain cables, and they are to be duly connected together in great lengths, and secured to the frames in such manner as to make the top surface smooth, and free from all obstruction to the motion of the carriages. Between each frame there are to be introduced three or four cast-iron braces, to prevent vibration and stiffen the structure. The method proposed for dragging the carriage along the railway, is by fixed or stationary engines acting with drag-lines or ropes attached to the carriage, which, if the railway be double, (as in the subjoined illustration) will act in an endless round; but if the line of railway be single, then the engine will be nterchangeable and reciprocal.

Fig. 1.

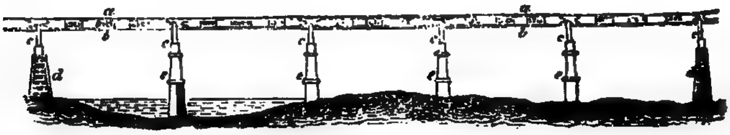


Fig. 1 represents a side elevation of one span of a double suspension railway, supported at the extremities by a pier of masonry, *d d*, and at equal distances by four cast-metal pillars *e e e e*. *a* is the upper or "bearing rail;" *b* the lower or "safety rail," which are bound together by intermediate stay braces, better shown on a larger scale at *f f* in figures 2, 3, and 4.

Fig. 2.

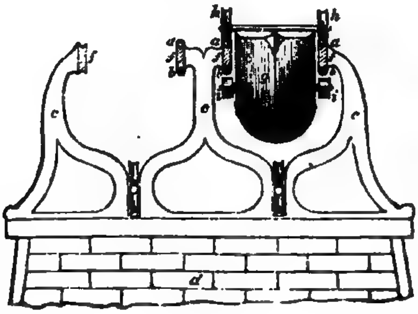


Fig. 3 shows a front elevation of a frame *c c c*, for a double line of rail, with arriage on one of them at *g*. The letters of reference in this figure, as in the others, designate similar parts; it therefore need only be said, that the braces *f f* are seen in section between the rails *a b*.

Fig. 3 gives a side elevation of a carriage on a portion of rail; *h h h* being running wheels, and *i i i* the anti-friction rollers, which prevent the carriage m being thrown off the railway. An examination of *Fig.* 2, which exhibits end view of this carriage, will fully explain its form and construction.

Fig. 3.

Fig. 4.

Fig. 4 is a perspective sketch of one of the stay braces on a larger scale. expense of one mile of railway on this principle is calculated at 1395*l.* 10*s.* 6*d.* e advantages contemplated are stated by Mr. Dick as follows: "In the first ce, as you save distance, so do you save time; which all must admit, that in commercial as well as in a political point of view, is of the utmost importance. e suspension rail takes a straightforward point from one town to another, hout regard to the surface of country over which it has to go, whether rising falling, crossing of rivers, or otherwise. All are, by regulating the heights the pillars, with the same ease gone over, and by that means saving of tance, saving of surface ground, saving bends in the formation of the rail; ich bends, besides the extra expense of originally laying, are always liable to at derangement from the lateral friction of the waggons coming round m, compared to that of a straight line of rail. Secondly, the suspension lway, over that of the ground railway, has another immense advantage; at is, as far as expense is concerned, which is, in the saving of all embank-nts, excavations, building of bridges, cutting of tunnels, besides the great alth of surface ground. Thirdly, and which I think the most important all, is the great despatch to be gained by the suspension railway, without, in least degree, endangering either persons or property, its height being suffi-nt at all places to allow every agricultural and commercial intercourse to go der it without interruption: and then the carriages being so completely ced within the rail prevents any chance of their escape, whatever may be ir velocity."

We conclude our account of the second era, by a notice of the construction he Manchester and Liverpool Railway.

Liverpool is the port whence Manchester receives all her raw materials, and which she returns a large portion of manufactured goods for shipment to all ts of the world. By means of the railroad, the transit of goods is now ected in about one eighteenth part of the time previously occupied by the ter conveyance of fifty miles, besides a saving of fifty per cent. in the cost ton of carriage; and these two great towns are by thirty-one miles of rail-y, as much connected for the purposes of business or pleasure, as the eastern western extremities of London. The undertaking was commenced in June, 6, under the direction of Mr. George Stevenson. It runs in nearly a straight e. The following are the gradients of the line:—

	Miles.	Yds.	Planes.
unnel under the Town of Liverpool, from Wapping to Edge-hill	1	240	Rise, 1 in 48.
evel	0	1000	Level.
o the Foot of Whiston, or Rainhill Plane	5	220	Fall, 1 in 1092.
ainhill inclination	1	880	Rise, 1 in 96.
ainhill level	1	1540	Level.
Carried forward	10	360	

	Miles.	Yds.	Planes.
Brought forward	10	360	
Sutton plane	1	880	Fall, 1 in 96.
Parr Moss	2	880	Fall, 1 in 2640.
Ditto	6	880	Fall, 1 in 880.
Chat Moss	5	880	Rise, 1 in 1200.
To Manchester	4	880	Level.
Total	30	1240	

The Tunnel under Liverpool was constructed in seven or eight separate lengths, each communicating with the surface by means of perpendicular shafts. About half-a-mile from the tunnel the railroad crosses Wavertree-lane; half-a-mile to the north of Wavertree, at Olive Mount, there is an excavation through the solid rock, 70 feet below the surface, and two miles in length. The road is then carried by means of a great embankment, varying from 15 to 45 feet in height, and from 60 to 135 feet in breadth, at the base, across a valley at Roby, or Broadgreen, two miles in length. It then crosses the Hayton turnpike road a little past Roby; six miles and three quarters from Liverpool, there is a junction railway for the conveyance of coals from the neighbouring mines on the right, and at a distance of seven or eight miles from the Liverpool station, it comes to the Whiston inclined plane, which is one mile and a half long, and rises about 1 in 96.

There is stationed here an assistant locomotive to aid the carriages in their ascent. For nearly two miles the road is then on an exact level. It was on this part of the road that the contest of locomotive carriages, for the premium of 500*l.*, took place in October, 1830, the result of which determined the directors to make use of locomotive engines instead of stationary ones. About half a mile from the Whiston plane, at Rainhill, the Liverpool and Manchester turnpike road crosses the railway, at an angle of thirty-four degrees. On leaving the level at Rainhill, the railway crosses the Sutton inclined plane, which is of the same extent as that at Whiston, and descends in the same proportion that the other rises; there is here another assistant engine.

The next object of interest is Parr Moss, the road over which is formed principally of the clay and stone dug out of the Sutton inclined plane, and extends about three quarters of a mile. The moss was originally about twenty feet deep, and the embankment across it is nearly twenty-five feet high, though only four or five feet now appear above the surface, the rest having sunk below it. The road is then carried over the valley of Sankey, by means of a massive and handsome viaduct, consisting of nine arches, of fifty feet span each, the height of the parapet being seventy feet above the Sankey canal in the valley beneath. The viaduct is built principally of brick, with stone facings, and the foundations rest on piles of from twenty to thirty feet in length, driven into the ground. The breadth of the railway between the parapets is twenty-five feet. The viaduct is approached by a stupendous embankment, formed principally of the clay dug from the high lands surrounding the valley. A little to the south of the town of Newton the railway crosses a narrow valley, by the short but lofty embankment of Sandy Mains, and a handsome bridge of four arches, each of forty feet span, under one of which passes the Newton and Warrington turnpike road. The Wigan and Newton branch here enters the railway.

A few miles beyond Newton is the great Kenyon excavation, from which above eight thousand cubic yards of clay and sand were dug out. The Kenyon and Leigh junction railway here joins the Liverpool and Manchester line, and as it also joins the Bolton and Leigh line, brings into a direct communication Liverpool and Bolton. The Liverpool and Manchester railway then passes successively under three handsome bridges; and a little beyond Culcheth, over the Brosely embankment, which is about a mile and a half in length, and from eighteen to twenty feet in height. It then passes over Bury-lane, and the small river Gless or Glazebrook, and a river at Chat Moss. This is a bog

prising an area of about twelve square miles, so soft that cattle cannot r it, and in many parts so fluid that an iron rod laid upon the surface ak to the bottom by the effects of its own gravity. It is from ten to e feet deep, and the bottom is composed of clay and sand. Hurdles wood and heath are placed under the wooden sleepers, supporting the r the greatest part of the moss, and the road may be said to float on face. The most difficult part was on the eastern border, extending lf a mile, where an embankment of about twenty feet in height de, and many thousand cubic feet of earth sank into the moss and red before the line of road approached the proposed level. At length, , it became consolidated; in 1829 one railway was laid over the whole nd on the 1st of January, 1830, the Rocket steam-engine, with a and passengers, passed over it. The line extends across the moss, a of about four miles and three quarters; and the road is not inferior to r part of the railway.

ving Chat Moss, the road passes over the lowlands at Barton, extendt a mile between the moss and Worsley canal by means of an ment; it is carried over the canal by a neat stone viaduct of two arches. proceeds through Eccles, and a portion of Salford, under six bridges; ied over the Irwell by a handsome stone bridge of sixty-three feet span, et from the water; and then over twenty-two brick arches, and a er Water-street to the company's station in Water-street, Manchester, e of thirty-one miles from the Liverpool station. The railway is there l with the second story of the Company's warehouses.

llowing general abstract of the expenditure upon the work, up to 31st 830, showing the cost of the different branches of the undertaking, found useful for comparison with the cost of more recent works of the

	£	s.	d.	£	s.	d.
sing account				£332	1	4
making account				9,721	4	4
account				99,065	11	9
for direction				1,911	0	0
for fencing				10,202	16	5
tablishment				461	6	3
Moss account *				27,719	11	10
s and embankments †				199,763	8	0
g department, comprising ac- t expended in land and buildings stations and depôts, warehouses, s, &c., at the Liverpool end	£35,538	0	0			
ded at the Manchester station	6,159	0	0			
nnel	2,485	0	0			
ht account, including cost of s, gasometer, &c.	1,046	0	0			
, coaches, machines, &c.	10,991	11	4			
				56,219	11	4
Carry forward				£405,399	11	3

ankments included under this head consist of about 277,000 cubic yards of raw moss formation of which, about 677,000 cubic yards of raw moss have been used; the difement being occasioned by the squeezing out of the superabundant water, and mpression of the moss. The expenditure on this part of the line has been less than expenditure.

is head is comprised the earth work on the whole line, exclusive of the Chat Moss e cuttings somewhat exceed the embankings, the surplus is principally deposited edge of the Great Kenyon Cutting. The excavations consist of about 722,000 cubic and stone, and about 2,000,000 cubic yards of marl, earth, and sand. This aggregate n removed to various distances, from a few furlongs to between three and four miles; onsiderable portion of it has been hoisted up by machinery, from a depth of thirty to be deposited on the surface above, either to remain in permanent spoil banks, or to be rried to the next embankment.

Brought forward				£405,399	11	3
Formation of the road *				20,568	15	5
Rail account				67,912	0	0
This expenditure comprises the following items:—						
Rails for a double way from Liverpool to Manchester, with occasional lines of communication, and additional side-lines at the different depôts, being about 35 miles of double way = 3,847 tons, at prices averaging something less than 12*l.* 10*s.* per ton	£48,000	0	0			
Cast-iron chairs, 1,428 tons, at an average of 10*l.* 10*s.*	15,000	0	0			
Spikes and keys to fasten the chairs to the blocks, and the rails to the chairs	3,830	0	0			
Oak plugs for the blocks	615	0	0			
Sundry freights, cartages, &c.	467	0	0			
Interest account (balance)				3,629	16	7
Land account				95,305	8	8
Office establishment				4,929	8	7
Parliamentary and law expenditure				28,465	6	11
Stone blocks and sleepers †				20,520	14	5
Surveying account				19,829	8	7
Travelling account				1,423	1	5
Tunnel account				34,791	4	9
Tunnel compensation account				9,997	5	7
Waggons used in the progress of the work				24,185	5	7
Sundry payments for timber, iron, petty disbursements, &c.				2,227	17	3
Total				£739,185	5	0

About 100,000*l.* more were required to complete the work.

In the formation of the railway, there have been dug out of the differe excavations upwards of three millions of cubic yards of stone, clay, and so which is equal to, at least, four millions of tons!

After mature consideration of the reports and calculations of various enginee appointed to consider the most eligible description of power for the Manches and Liverpool railroad, they determined in favour of locomotive engines, pr vided they could be made sufficiently powerful, and at the same time not of great a weight as to injure the stability of the rails, and without emitting smo which is one of the provisions of the Railway Act. With the view also obtain, if possible, an engine of improved construction, a public reward w offered by the directors in April 1829, for the best locomotive engine, subject certain stipulations and conditions, which may be thus briefly stated: viz. consume its own smoke: to be capable of drawing three times its own weig at ten miles an hour, and with a pressure not exceeding 50lbs. upon the squ inch on the boiler: two safety valves, one locked up: engine and boi to be supported on springs, and rest on six wheels if it should exceed 4½ ton height to top of chimney not more than 15 feet: weight, including water boiler, not to exceed 6 tons; but preferred if of less weight: boiler, &c. prov to bear three times its working pressure: pressure gauge provided: cost machine to be not more than 550*l.*

* By this is understood what is termed ballasting the road,—that is, depositing a layer of bro rock and sand, about two feet thick; viz. one foot below the blocks, and one foot distributed betw them, serving to keep them firm in their places. Spiking down the iron chairs to the block sleepers, fastening the rails to the chairs wi h iron keys, and adjusting the railway to the e width, and curve, and level, come under this head of expenditure.

† Out of thirty-one miles, eighteen are laid with stone blocks, and thirteen with wooden slee of larch; the latter being laid principally across the embankment and across the two dist of moss.

On the day appointed, the following engines were entered for trial for the prize; and the judges appointed to decide were, Mr. Nicholas Wood, of Killingworth, (to whose labours we stand much indebted in this article,) Mr. Rastrick, of Stourbridge, and Mr. Kennedy, of Manchester, who made judicious arrangements.

The *Rocket*	Steam locomotive,	by Mr. Robert Stevenson.
The *Novelty*	ditto	by Messrs. Braithwaite & Erricson.
The *Sans Pareil*	ditto	by Mr. Timothy Hackworth.
The *Perseverance*	ditto	by Mr. Burstall of Edinburgh.
The *Cycloped*	Horse locomotive,	by Mr. Brandreth of Liverpool.

The trial, as before mentioned, took place on the level at Rainhill. Several days were employed in getting them into the best working condition for the contest.

	Ton.	cwt.	qr.	lb.
The *Rocket* weighed . . .	4	5	0	0
Tender, with water and coke .	3	4	0	2
Two loaded carriages attached	9	10	3	26
Total weight in motion . .	17	0	0	0

The rate of performance of this engine was found by the judges to be 70 miles in about five hours, or 14 miles per hour; with an evaporation of 114 gallons per hour, and a consumption of coke of 217lbs. per hour. The greatest velocity attained was on the last eastward trip, the 1½ mile being accomplished in 3' 44", which is at the rate of 24⅛ miles per hour.

On the following day the next engine brought up to the starting post was the *Sans Pareil*, but on weighing, it was found to exceed the condition of 4½ tons on *four* wheels, therefore could not strictly compete for the prize. Nevertheless, it underwent a trial of its powers, in order that the Directors might be acquainted with its merits.

	Ton	cwt	qr.	lb.
The weight of the *Sans Pareil* . .	4	15	2	0
Tender with water and fuel . . .	3	6	3	0
Three loaded carriages attached .	10	19	3	0
Total weight in motion . . .	19	2	0	0

In making the eighth trip on the running ground, the pump that supplied the water to the boiler became disordered in its action, by which the level of the water in the boiler became reduced below the fire tube, and the leader plug, employed as a safety valve, was melted, and put an end to the experiment. As far as the experiment was conducted, which extended to 27½ miles, the performance was creditable, being 19¼ tons conveyed at the rate of 15 miles per hour. The greatest velocity attained was in the fifth trip; the 1½ mile being performed in 3' 59", which is at the rate of 22⅝ miles per hour. The consumption of the coke in this engine was enormous, being at the rate of 692lbs. per hour, which was found to be owing to the draft through the fire-place being so powerful, as to blow red-hot cinders out of the chimney shaft.

The *Novelty*, which was not tried until the 10th, owing to unavoidable circumstances, carried its own water and fuel; and, therefore, to place it on the same footing as the other engines, the same proportion of useful load was attached to it when compared to the engine, as the useful loads taken by the other engines have to their weight. The power and its load were accordingly as follow:—

	Ton.	cwt.	qr.	lb.
Weight of the *Novelty*, with water in the boiler .	3	1	0	0
Tank, water, and fuel	0	16	0	14
Two loaded carriages attached	6	17	0	0
Total weight in motion	10	14	0	14

In the early part of the trial with this engine, the water supply-pipe burst,

and put an end to the experiment for that day. Two or three days afterwards the trial was renewed, but another unfortunate accident (that of one of the joints of the boiler giving way) terminated the proceedings, at the desire of Mr. Erricson, who voluntarily withdrew his carriage from the contest. The performance of the engine, while it lasted, indicated very excellent results; the design, arrangement, and execution of the work, were likewise highly creditable to the genius and talent of the proprietors.

The *Perseverance*, after a short trial, was proved unsuited to the railway, and was immediately withdrawn by the proprietor. The course was thus left clear for Mr. Stevenson to receive the fairly won prize of 500*l*., which was awarded to him by the judges.

The *Cyclopede*, though included in the foregoing list of rival machines, not being propelled by the power mentioned in the "stipulations and conditions," it could not be properly considered as entering the lists for the *prize* therein proposed; it was, however, an inquiry well worth the investigation, what degree of power horses could exert in a locomotive machine of the kind, and thereby determine its comparative economy with that of steam. For these reasons a trial of the *Cyclopede* took place; but it only attained a speed of five or six miles an hour, owing, as we believe, to the horses not having sufficient power to exert themselves in their stalls, as well as to an injudicious construction of some parts.

To discover the cause of the great increase of speed, and the variable quantities of fuel consumed by the different locomotive engines, which competed for the prize at the Manchester and Liverpool railway, Mr. Wood instituted the comparative view of each, which is exhibited in the following table:—

Names of Engines.	Area of Fire grate in feet.	Area of *radiant* Surface, in feet.	Area of *communicative* Surface, in feet.	Cubic feet of Water evaporated per hour.	Pounds of Coke required to evaporate a Cubic Foot of Water.
Rocket . . .	6.	20.	117.8	18.24	11.7
Sans Pareil .	10.	15.7	74.6	24.	28.8
Novelty. . .	1.8	9.5	33.		
Old Engines.	7.	11.5	29.75	15.92	18.34

"In examining the above, we find a very important effect in the economy of fuel, produced by the *Rocket* over the old engines, in the proportion of 11.7 to 18.34, supposing the heating powers of coke and coal be equal. The cause of this is very obvious, and is entirely attributable to the use of the tubes of small diameter, presenting such an area of surface to the water in the boiler. These tubes were used at the suggestion of Mr. Booth, treasurer to the Liverpool and Manchester Railway Company, and nothing, since the introduction of those engines, has given such an impulse to their improvement.

"With a less area of fire-grate than the old engines, the surface exposed to the radiant heat of the fire is as 20 : 11.5, and the surface exposed to the communicative power of the heated air and flame, as 117.8 : 29.75, nearly four times as great.

"Nor is this the only difference; in the old engines the *area* of the tube (of 22 inches diameter) for the passage of the flame and heated air to the chimney, was 380.13 inches; and of this large body of flame and air passing through the tube, only an extent of surface of 69.11 inches was exposed to the water in the boiler. In the *Rocket* engine, the area of heated air and flame in 25 tubes, 3 inches each in diameter, was 176.7 inches, while the surface exposed was 235.6 inches.

"It is not necessary, perhaps, to pursue the comparison further. The economy of fuel which must result from the exposure of so much greater surface to the water, cannot fail to insure a more perfect abstraction of the heat, and thus

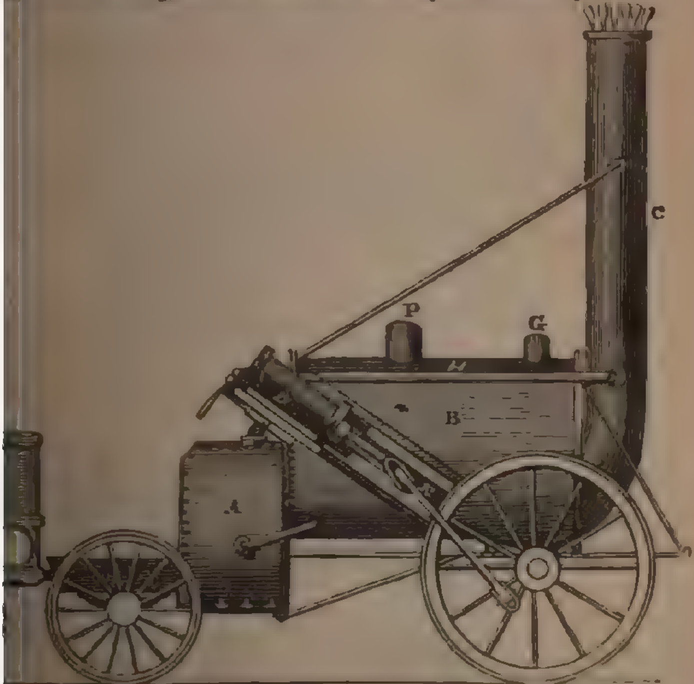
ave the fuel, but prevent great part of the previous destruction of the by the intense heat of the *wasted* caloric.

ame remarks apply to the *Sans Pareil* of Mr. Hackworth, as to the old hough in a less degree. In the *Rocket*, the surface exposed to the at of the fire, compared with the area of fire-grate, is as $3\frac{1}{8}$: 1, while s *Pareil*, it is only $1\frac{1}{4}$: 1; the same proportion as in the old engines. cket, the surface exposed to the heated air and flame, compared with fire-grating, is as $19\frac{2}{3}$: 1; while, in the *Sans Pareil*, the proportion : 1. The bulk of air passing through the tube of the latter, will, at o the chimney, be 176.7 square inches, the exposed surface being 25 : 1, nearly; while, as before stated, the bulk of air passing through of the *Rocket*, is 176.7 inches, or precisely that of the *Sans Pareil*, surface exposed, is 235.6 inches, or $1\frac{1}{3}$: 1. These will sufficiently r the great difference in the economy of fuel between the two engines, requiring only 11.7 lbs. to convert a cubic foot of water into steam, *Sans Pareil* required 28.8 lbs."

g now stated the results of this memorable contest, it becomes neces- ve some account of the machines engaged therein.

cket, constructed by Mr. Stevenson, of which an external side elevation the following figure, possesses many of the characteristics of the reviously used; but the furnace and boiler have considerable claims and effectiveness.

nace at A is a square box, about 3 feet wide and 2 feet deep. This fur- e external casing, between which and the fire-place there is a space of 3



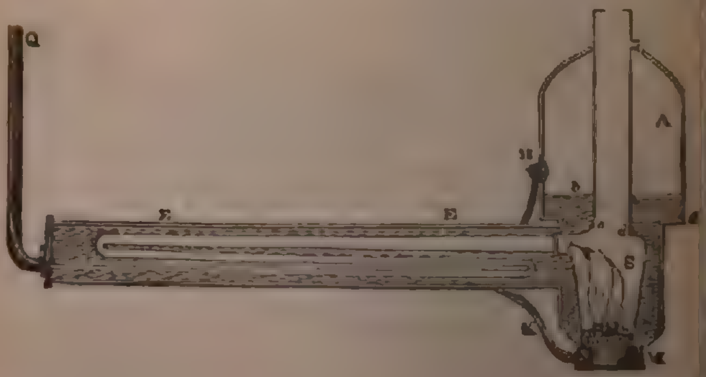
d with water, and communicating by a lateral pipe with the boiler. d air, &c. from the furnace passes through twenty-five copper tubes, diameter, arranged longitudinally on the lower half of the boiler, and the chimney C. D represents one of the two steam cylinders,

which are placed in an inclined position on each side of the boiler, and communicating by their piston rods, through the media of connecting rods E, motion to the running wheels. P G are safety valves; E is one of two pipes on each side of the boiler, by which the eduction steam from the cylinders is thrown into the chimney, and by the exhaustion thus caused in the latter, producing a rapid draft of air through the furnace. At M is exhibited part of the tender, which carries the fuel and water for the supply of the engine.

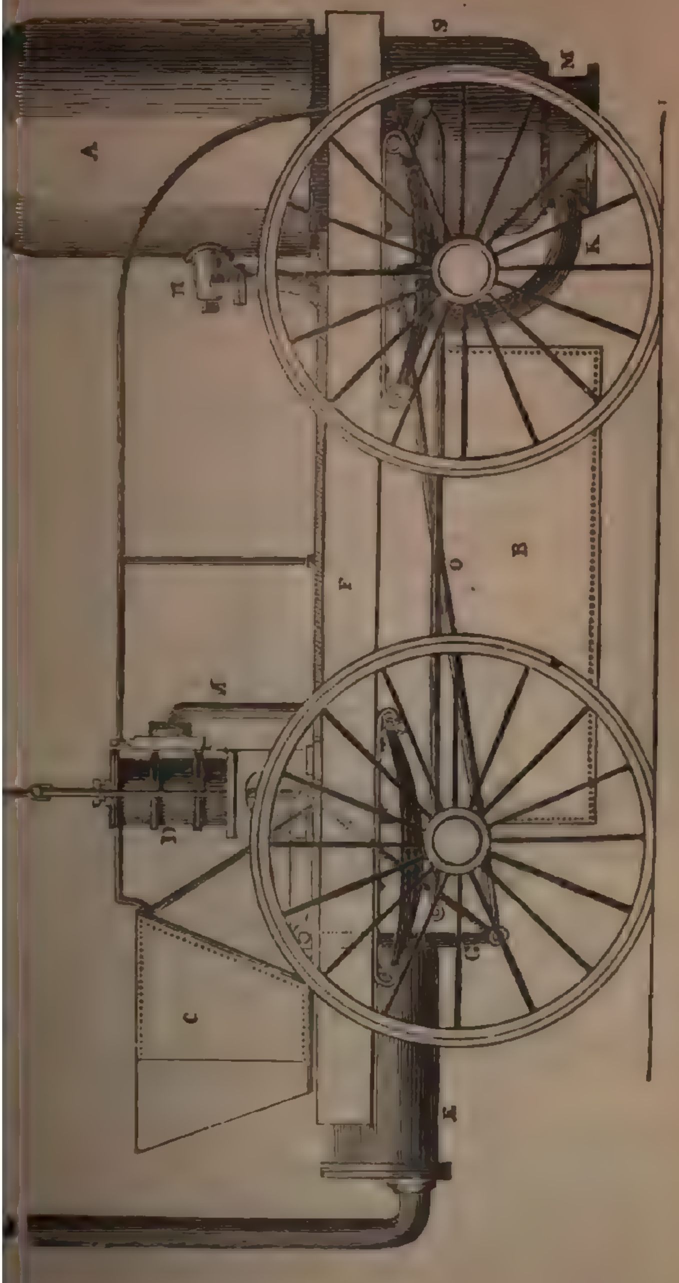
The *Novelty*, by Messrs. Braithwaite and Erricson, is exhibited in the opposite page, representing a side elevation of the machine.

F is the carriage-frame; E, one end of a long horizontal cylinder, forming the principal part of the boiler, which extends to the large vertical vessel A, at the other end of the carriage, and contains forty-five gallons of water; L, a hopper to supply the fuel, (which is carried in small baskets placed on the carriage,) whence it is conducted by a tube in the centre of the steam-chamber A, into the furnace S, beneath. At C is a blowing machine, the air from which is conducted by a pipe under the carriage, and proceeding by the tube K enters the ash-pit M, under the furnace; Q is a pipe for the escape of the heated gases after the combustion, and forms the only chimney used; B is the water-tank; at D N are two working cylinders with their steam-pipes and valves; the cylinders are six inches in diameter, and have a twelve inch stroke; O G are connecting-rods, which impart the force of the engines to the running-wheels. The axletrees are fixed to an iron rod, and slings are introduced to prevent the side action between the rod and the carriage-frame; and to prevent the effect of the springs from counteracting the action of the engine, the connecting-rods are placed as nearly as possible in a horizontal position, and the motion is communicated to them by bell-cranks on each side of the carriage, being connected by the slings to the piston-rods. The pistons used are the patent metallic of Barton; and the running-wheels, the patent suspension kind of Theodore Jones and Co.

The figure below exhibits a section of the boiler introduced by Messrs. Braithwaite and Erricson, into the *Novelty* steam-carriage. S is the furnace surrounded by water; and L the tube by which the fuel is supplied to feed the fire; M is the ash-pit, through which the air is forced by the pipe K from the bellows of the engine. The vessel containing the water that surrounds the furnace, and the long cylinder that proceeds horizontally from it, constitute the



boiler, as shown at E E e. The flames and heated air from the furnace, after ascending by the action of the bellows, enter a long tortuous flue, which makes three turns in the entire length of the horizontal boiler, escaping finally at the chimney. The fuel in the furnace has, therefore, a direct action upon the water surrounding it; and the water in the long cylinder is operated upon by the



gases in the flue, which gradually tapers from the furnace to the ch[illegible] has a constant inclination downward, and as the whole of the [illegible] flue is surrounded by the water of the boiler, there can evidently b[illegible] of the heat misapplied.

The *Sans Pareil* of Mr. Hackworth is represented in elevation [illegible] joined cut. The boiler B is cylindrical, of the Trevithick kind, wit[illegible] ends convex outwards, and the other flat. The fire-bars were of g[illegible] than usual, having an area of ten feet; and the flue-tube is returned [illegible] on one side of the fire-place, where it enters the chimney C. D re[illegible] of the two working-cylinders; these were seven inches in diamet[illegible] an eighteen-inch stroke. The piston rods, through the medium of [illegible] connecting rods, operated upon the hind pair of wheels; and the [illegible] connected to the fore wheels by the horizontal connecting rods, sho[illegible] the manner of cranks, motion was communicated to both pairs of [illegible] arrangement which is designed to cause a greater adhesion of the wh[illegible] rails, and of enabling the carriage to draw a greater load, than if o[illegible] of wheels was operated upon.

The Sans Pareil.

SECTION II.

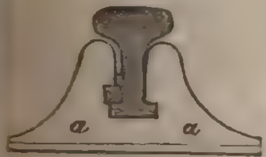
THE CONSTITUENT PARTS OF RAILWAYS.

Stephenson's and Losh's Rails and Chairs.—Jessop's Chairs and Pedestals.—Stephenson's patent Chairs and Fastenings.—Scrivenor's patent wrought-iron Chairs.—Reynold's patent continuous bearing rails and Sleepers.—Parkins's patent Vitrified Sleepers.—Permanent way of the Great Western Railway.—Permanent way of the South Eastern Railway.—Brighton and Hastings permanent way.—Orsi's patent Chairs and Sleepers.—Switches.—Curtis's patent Switches.—Turntables.—Hancock's patent Turntable.—Mallett's hydrostatic Turntable.—The broad and narrow Gauges.—Parliamentary Commission thereon.—Inconvenience of breaks—as applied to Passengers—to Merchandize—and to Troops.—Expedient of Telescopic Axles.—Loaded waggons on Trucks.—Shifting on Wheeled Platforms.—Intermediate Rails.—Policy of uniformity of Gauge.—Comparative safety of different.—Accommodation and convenience.—The best adapted for speed.—Accidents on each.—Economy of each.—Deductions from the evidence.—Recommendations to Parliament.—Water Crane.—Cleansing Rails.—Curtis's Screw Jack.—Cost of various Railways per Mile.

The general nature and construction of Railways having been explained and illustrated in the previous Section, we proceed, in this division of our subject, to give a more enlarged and precise description of their constituent parts; especially as relates to the improvements in such as have been devised since the opening of the Manchester and Liverpool Railway.

We shall commence with a brief account of the rails, chairs, and sleepers used by Mr. Stephenson in the formation of the Manchester and Liverpool Line, which was omitted in our account of that Railway.

The annexed cut shows a transverse section of the rail *r*, which has a lateral rib on one side, fitting into a corresponding cavity made in the cast-iron chair *a*. On the opposite side of each chair another cavity is cast, to receive an iron key *b*, wedge-formed, which, pressing against the side of the rail, forces the projecting rib into the cavity on the opposite side, and locks the bar into its required position.



A form slightly varying from the foregoing was introduced by Mr. Losh as shown in the annexed cut. In this the projections are rolled on both sides of the bar; one of these projections enters the cavity in the chair, like the former. On the other cheek of the chair is cast a longitudinal notch for receiving double key wedges as shown; which act at the same time upon the upper part of the projection on the rail to force it down upon the chair and against the side of the rail to steady it, and force the projection on the other side of the rail into the cavity. By this mode of keying it was considered, that if the rail worked loose upon the chair, by driving the key, it could be tightened.

Jessop's Patent Chairs and Pedestals.—To obviate the inconvenience frequently resulting by the sleepers or blocks sinking in the soil or losing their perpendicularity; and hence of destroying the level or parallelism of the rails, Mr. Jessop patented in 1833 a method of framing the chair distinct from the pedestal, the latter being fixed firmly to the sleeper, and the chair being united to the pedestal by a universal joint or hinge. This arrangement permits the pedestal to adapt itself to any irregular sinking of the block or sleeper on which it rests, and insures a firm and solid bearing upon its base. The patentee

also effects it by the combined motion of a hinge joint, or other means p mitting motion between the pedestal and the chair, and a moveable joint form at the junction of the chair and rail, so as to produce the same effect. T following drawings represent several methods of constructing the unive joint, in all of which *r r* are the rails, *c c* the chairs, *p p* the pedestals, *b b* the blocks or sleepers; *j j* are the junction bars of cast or wrought i by which the opposite chairs are connected together, and the rails are then held parallel to each other, and at a proper distance apart, and are retained in a suitable position to insure a flat bearing on the surfaces of rails for the wheels to travel upon; *s s* are cast-iron bed-plates or sleep (which may be used to support the rails where stone is expensive,) so construc that the pedestal may be readily adjusted, by the introduction of a wedge packing, to a proper level, without disturbing the seats which the bed-pl may have acquired on the ground; the same method of construction be applicable to the pedestals, when they are attached to stone blocks.

Fig. 1 is a side view of its adaptation to the ordinary railway in use in north, at the period of the invention.

Fig. 1.

Fig. 2 shows the plan; and *Fig.* 3, the cross section. Two of the stone blo *b* are drawn in an inclined position to show the action of the pedestal.

Fig. 2.

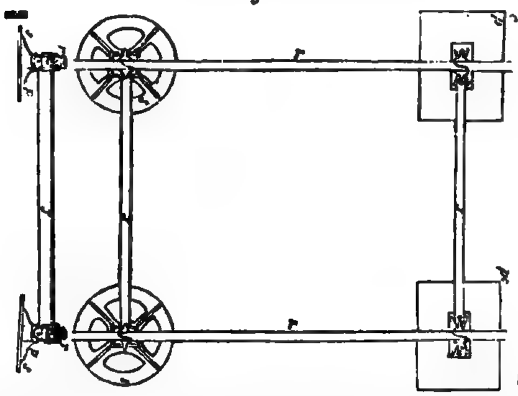


Fig. 3.

Figs. 4 and 5 are sections of the pedestal and chair, showing an orbic universal joint, by means of which the pedestal adapts itself to any irreg sinking of the stone block or other sleeper, whilst the connecting or junc bars retain the rails in their proper gauge, and their opposite surfaces in same plane or straight line.

Fig. 4.

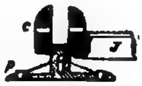


Fig. 5.

Figs. 6, 7 and 8, are other views of the pedestal and chair.

Fig. 8.

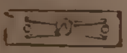


Fig. 7.

Fig. 6.

Figs. 9, 10 and 11, are a side view, plan, and sec-
tion of a cast-iron bed-plate, used as a substitute for
the stone blocks; showing also the method of ad-
justing the rails by means of wedges or packings
introduced between the bed-plates and the base of
the pedestal, which is made to fit in the recess
formed in the bed-plate, and secured laterally by
means of a wedge or key. The patentee states his
claim to consist in "constructing railways, to *the*
using of chairs and pedestals, which are capable of
turning or moving on universal or other similar joints,
as above described, whereby the railway will not be
so liable as heretofore to be deranged by the sinking
of the blocks or sleepers, whether of stone, wood,
iron, or other material."

Fig. 9.

Fig. 10.

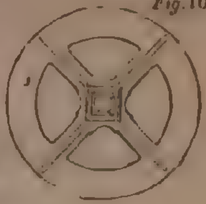


Fig. 11.

Stephenson's Patent Chairs and Fastenings.—Owing to the effects of expansion and contraction, and the violent shocks and strains to which the fastenings of a railway are subjected, the task of perfecting these parts of the mechanism has until recently been found one of difficult accomplishment. With the view of remedying the defects then existing, Mr. Robert Stephenson obtained letters patent in 1833 for certain modes of providing firm and secure bearings at the bottoms of the notches in the chairs for the rails to rest upon, these bearings being capable of self-adjustment, in order that they may adapt themselves correctly to the under parts of the rails; and the making of adequate provisions for fastening the iron rails securely downwards, upon such self-adjusting bearings, as well as for confining the rails laterally within the notches in the chairs, but in such manner that the self-adjusting bearings will not be subject to be deranged, nor the fastenings to be loosened, by the effect of any such slight tilting or inclination of the chairs in the direction of the length of the rails, as may result from the partial or unequal subsidence of the ground beneath the stone blocks or wood sleepers upon which the chairs are fastened, nor by the effects of any such slight elongations or contractions in the length of the rails as they are usually liable to from ordinary changes of temperature."

Mr. Stephenson's mode of effecting this, is by the application of a self-adjusting segmental bearing piece, into a suitably formed concavity made below the level of the bottom of the notch of each chair; the flat or chord side of the segmental piece being uppermost, and forming the bearing surface at the bottom of the notch in the chair. Upon that flat bearing surface, the under side of the rail is to rest, so that the bearing surface will always accommodate itself to the under side of the rail, and form an even contact therewith; in consequence of the circular side of the segmental piece adapting itself to the required position, by turning in its concave cell. Having thus explained the general arrangement of the parts, it will not be requisite to enter into the detail introduced into the specification, as sufficient knowledge will be obtained by the insertion of the following illustrated figures, and description of them:—

Fig. 1 is a perspective view, and *Fig.* 2 a lateral elevation; *Fig.* 3 a transverse section, and *Fig.* 4 a horizontal plan of a chair, for supporting and uniting the extremities of the lengths of iron rails for edge-railways. A A is the flat

bottom or base of the chair, which is to be bedded upon the block or sleeper, and fastened thereto by spikes driven through the holes *a a*.—B B are the cheeks of the notch in the chair, that notch being the parallel space which is left between the cheeks for the reception of the rails C *c* D *d*, which may join together with a half lap joint, as shown in perspective at *Fig.* 1, and in the plan *Fig,* 4, the overlapping parts *c d* being of the same size, or nearly of the same size, as the other parts of the rails, and those parts are included within the

Fig. 1.

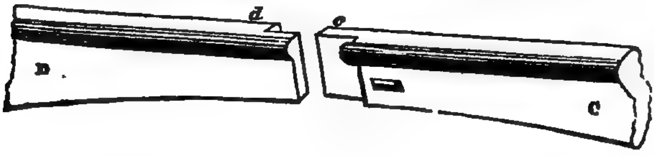


Fig. 2.

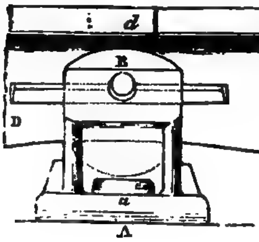


Fig. 3.

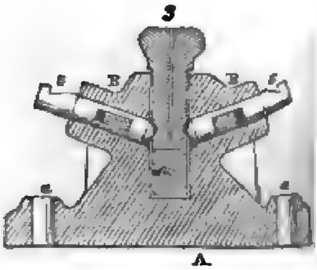
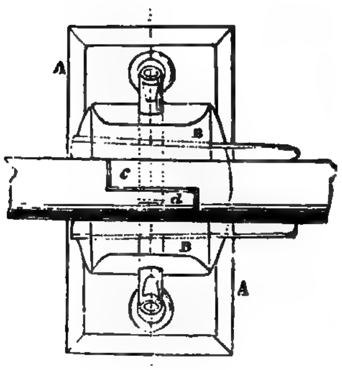
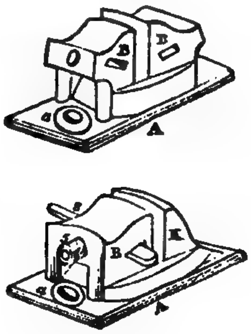


Fig. 4.

Fig. 5.

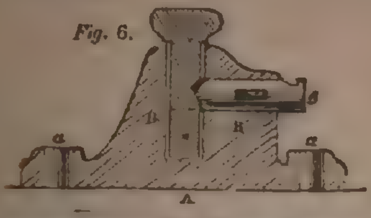




notch of the chair. The bottom of this notch is deeper than is necessary for receiving the rails, and is depressed into a concavity of a suitable form, for receiving the segmental bearing-piece which is shown on the next page, at 4 4 4, in plan, elevation, and perspective : the under edges of the rails rest upon the uppermost flat surface of this bearing-piece. The small figures 5 and 6 are cylindrical pins, which are fitted into cylindrical sockets, through each of the cheeks or sides B B ; and 8 and 9 are tapering or wedge-like keys, which are inserted through suitable mortices in the cheeks and across the pins 5 and 6,

the purpose of forcing forward those pins, so that their pointed extremities press obliquely upon the lower parts of the grooved recesses in the rails, a bearing-down action, to confine the rails downwards upon the bearing-, and laterally in the chair. The cylindrical pins are shown detached, in to explain the manner in which the pointed extremity applies into the ed recess in the rails, so as to exert a bearing-down action thereon. *Fig.* 5 ents perspective views, and *Fig.* 6 a transverse section of a chair for

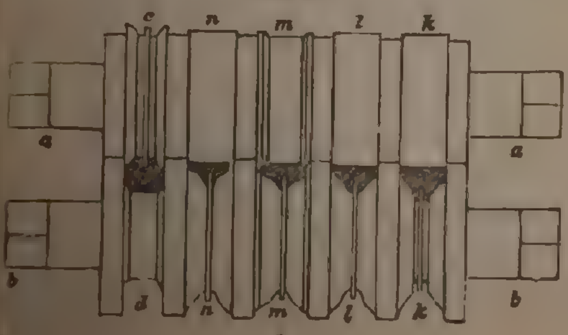
Fig. 6.



ting the iron rails at intermediate distances between the extremities or ons of their several lengths; it has only one cylindrical pin 5, fitted h one of its cheeks B, the opposite cheek K being a flat vertical surface, which the flat side of the rail is pressed and held firm, by the keying the cylindrical pin 5, so as to confine the rail laterally at the same time the oblique action of the point of the cylindrical pin 5, in the grooved of the rail, may produce a bearing-down action, which confines the rail upon the segmental bearing-piece. The chairs are made of cast iron; ckets for the cylindrical pins, the mortices for the wedge-like keys, and the or the segmental bearing-pieces, being formed in the casting, as well as les for the holding-down spikes; the wedge-like cross keys, the cylindrical and the segmental bearing-pieces, are made of wrought iron.

IVENOR'S PATENT WROUGHT-IRON CHAIRS.—The extensive destruction of dinary *cast*-iron chairs about fifteen years since, induced Mr. Scrivenor, 2, to attempt their formation of malleable iron by the rolling and die-g process. The following account we derive from the specification of tent.

Fig. 1.



In the preceding *Fig.* 1, *a b* represent a pair of cast-iron *rolls* designed f this object, and put in motion by the usual mechanism employed in iron-work It will be observed that the series of grooves or indentations in their peripher correspond with the several shapes which the metal is intended to take its progress through these rollers, until it at length attains the exact sha required to form the chairs or pedestals. Thus, for example, the grooves at c must be adapted to receive an ordinary short thick bar of wrought iron, ab two feet long, and six inches square, properly heated for rolling. The bar is fi passed through the rollers at *c d*, which causes it to assume the shape shown *j*. It is then passed in succession through the other grooves on the rollers *k k*, *l l*, *m m*, *n n*, whereby it successively takes the form shown at *e f g* Having thus obtained a long bar of iron of the sectional form shown at *n*, it next cut into lengths for chairs, which is effected by the mill shears shown *Fig.* 2, which are worked by the engine. These shears are provided wi steel jaws to receive the chair as shown at *v w*, in order that in cutting off th chair it may not be forced out of shape. The opening between the cheeks

Fig. 2.

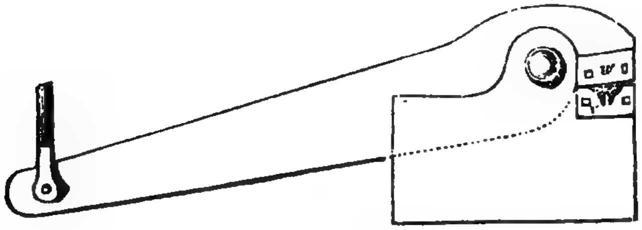
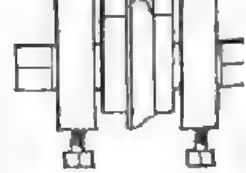


Fig 3.

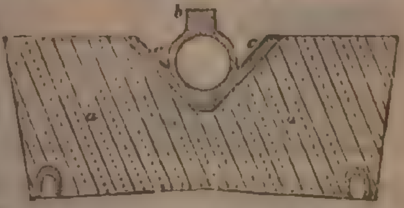


the chair for the reception of the rail are at present left parallel; the next process is therefore to give these parts a more suitable form for holding down the rail. This is effected by making the chair red hot, and placing inside the recess a mandril of the required shape, with which it is again passed through another pair of rolls shown in the annexed *Fig.* 3; by these the recess is impressed with the required form to adapt it for receiving the intended keys.

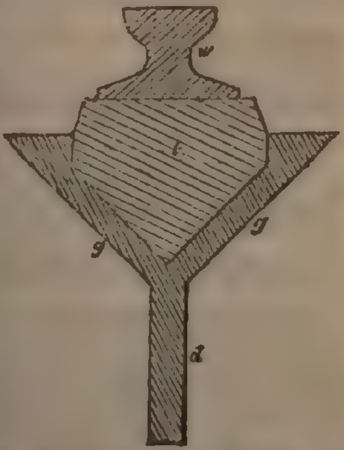
We have never seen any of the wrought-iron chairs of the kind just described in use; probably from the difficulty of bestowing upon them that finished form which is requisite, at a sufficiently low price. Although the brittleness of cast-iron seems at first sight to render it an improper substance for chairs, yet a little reflection on the other hand will show that it affords such facilities to the judicious engineer to provide the most effectual remedy to its natural defect, as to render it in opinion even more advantageous than wrought-iron. The immense break of cast-iron chairs a few years since was in a great measure owing to injudic forms, and not a little to bad execution in the foundries, rather than to the na of the material. This fact is satisfactorily proved by the perfection of form superior execution of the cast-iron chairs and fastenings on the South Eas and Dover Railway, manufactured we understand by Ransome and Ma Ipswich, which will be described a few pages onward.

Reynolds's continuous Bearings and Sleepers.—It has been obse that the deflection of the railway bars, by heavy carriages passing

...mbs a considerable portion of the tractive force; besides pro-...y their vibratory action, an earlier destruction of the stationary, ...e the locomotive mechanism. To provide a remedy for these ap-...fects of the ordinary system, Mr. John Reynolds, of Neath, pro-...give to the rails, bars, or plates, an equal support in every part of ...th, so that they shall not be susceptible of sensible depression or ...; and this he proposed to effect by two methods, for which he obtained ...on the 5th May, 1835. The first is by cast-iron bearers laid and ...to end, and in such manner as to be incapable of vertical or lateral ...l, independently of those next adjoining to it. The rails, bars, or ...er which the carriage-wheels are intended to run, may be either cast ...ith the bearers, or they may be separate. The second method is by ...rmed by blocks of natural or artificial stone, joined end to end, and ...the roadway, and secured in such manner together, that they can ...in concert. A great variety of forms of rails, founded upon the basis ...ction just mentioned, have been made by Mr. Reynolds: it will only ...power to notice here two or three of them. The annexed figure ...ertical section of one of the most approved forms, in which the ...that it is imbedded ...at *a a*, is of less ...the bottom of the ...pers generally used, ...siderably less depth ...ottom of the excava-...ballasting on the ...d Birmingham rail-...



...rm of the bearing ...e carriage wheels is ...b, and that of the hollow support and lateral inclined plates at *c c*. ...fastened end to end by means of "snugs," or projecting pieces cast ...of such forms that, when placed in juxtaposition, a key or wedge ...to an aperture formed by their union, which holds them firmly ... The blocks of natural or artificial stone are to be joined by the ...odes known to masons, and ...understood to need expla-... The annexed section repre-...ther of the numerous designs ...the patentee: *w* represents ...-iron rail, resting upon and ...to a sill of timber *t*, enclosed ...the bearing plates *g g*, which, ...with the fin *d*, are imbedded ...llasting.



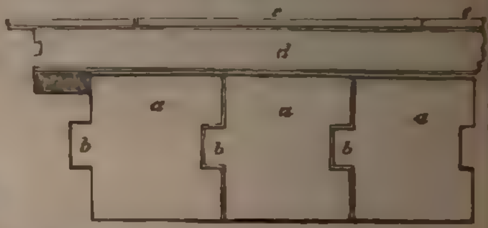
...dvantages contemplated by ...tee are—1, a great saving in ...and ballasting; 2, a saving ...st of materials and laying ...; in maintenance of way or ...ce of work; 4, saving the ...f engines. Some rails on ...ruction are laid down ex-...lly on the Liverpool and ...r line, and apparently stand ...ry satisfactorily.

...'s Petrified Sleepers.—Mr. Thomas Parkins, of Dudley, took out ...r a similiar object to the foregoing, in December 1835. It consists ...continuous sleepers of vitrified earth (burnt clay), which the patentee ...s hard and durable as granite, and impervious to the weather. The

following *Fig.* 1 gives a cross section of Mr. Parkins's railway, and *Fig.* 2 a si elevation of a portion of it. The vitrified blocks or sleepers are shown at a a each sleeper is 13 inches at the base, 5 at the top, 12 deep, and 9 long, a locks into the other, thus forming a continous mass along the whole line of ra The joining is effected by a projecting tongue *b*, which fits into a correspondi recess made in each block. A groove *c* is moulded longitudinally in the top of th sleepers, into which the rib of a wooden bearer *d* (four inches at the base, four de two wide at the top, and twelve feet or more long) is placed; and is bedded up patent felt; on this wooden bearer is fixed an iron bar *e e*, for the wheels of th carriages to run upon; this bar or rail being also bedded upon felt.

Fig. 1.

Fig. 2.



Mr. Parkins gives the preference to the arrangement described; but h proposes, in certain cases, to dispense with the wooden bearers *d d*, and to pla iron rails of the ordinary kind at once into the groove *c*.

Permanent Way of the Great Western Railway.—This line of rails i laid down throughout upon continous bearings, but the method of connecti the rails to those bearings, and of connecting the latter to the transverse sleepe or rather ties, is varied in different parts of the line. There are other variatio which our space will not permit us to enter upon, we have therefore select for our illustration that particular modification of the permanent way, to whi we understand Mr. Brunell gives the preference.

Fig. 1.

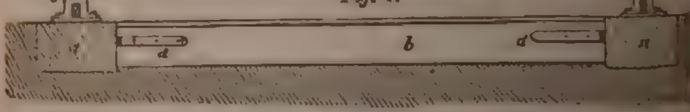


Fig. 2.

Fig. 1 represents a transverse section of the permanent way; and *Fig.* a longitudinal view. At *a a* are the longitudinal bearing timbers having scantling of about 15 × 9 and joined continuously through the line. Th timbers are united together at right angles by transverse ties *b b*, at about ev 9 feet distance; these are also of timber, about 6 inches by 9, and fastened means of straps and bolts *d d*. These ties preserve the parallelism of continous bearings. On the upper surface of the latter are laid thin boa of prepared hard wood, and fastened thereto by nails. The width of th boards is about 8 inches, and on them is laid the continous rail, in length about 15 feet each, end to end throughout. The form of these rails is that of denominated the "bog trough" or "bridge" rail; the shape is however pr

ndicated in *Fig.* 1, at *c c*. The same rail is shown in our account of the don and Hastings permanent way, on a larger scale. Mr. Brunell was entor of this form of rail, and it is undoubtedly a very efficient one.

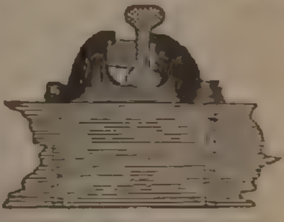
RMANENT WAY OF THE SOUTH-EASTERN RAILWAY.—The chairs, fastenings, sleepers employed on this line of railway are entitled to the particular tion of the engineer, on account of the good judgment and skilful execu- displayed in the details of the work; combining, as they appear to do, ality of structure with economy of material. A description of this anent way was furnished to the Institution of Civil Engineers, by John Pope, Grad. Inst. C. E. from which we shall make such few extracts have room for.

either side of the bank of ballast, and below the level of its bed, there is en drain, three feet in width, extending throughout the line, which ensures t drainage from beneath the sleepers. The sleepers are placed transversely, differ in shape from any hitherto employed. They are of Baltic fir, and rmed by a square balk being diagonally divided so as to cut out four gular sleepers, which are laid with the right angle c downwards, which form

balk divided to form four sleepers.

Triangular sleeper a b c, contrasted with half a balk.

has as much bearing surface as one of twice the cubic content cut out half balk in the usual manner. The advantages arising from this form in onomy of timber, the facility of packing, and the improved drainage of ballast in contact with the sleepers, are obvious. The chairs are of a ar form, designed by Mr. Cubitt to combine lightness with strength; they st on a plan invented and patented by Messrs. Ransome & May, of ch, whereby the inward inclination of ils, instead of being made to depend upon the rail layers, (as is usually the effected entirely by the shape of the , which are all cast with peculiar cy. The uniformity of inclination d by this improvement greatly bes that lateral motion of the carriage is commonly observed on other lines lway. The chairs are placed hori- lly on the sleepers, and are fastened with treenails of oak, compressed by nt process of Messrs. Ransome & May.



Elevation of Chair, showing the inclination of the Rail.

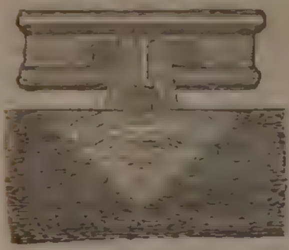
edges employed to secure the rails in the chairs are similarly compressed. ls are parallel, with their upper and lower tables of equal breadth, the al form of which is shown in the previous figure.

subjoined four figures (p. 422,) exhibit the end elevation and plan of a hair, and the end elevation and plan of an intermediate chair, which, ered in connexion with the preceding *side* elevation of the chair, will, oped, render the peculiar form understood.

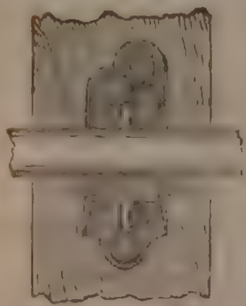
Cubitt's object has been to lay a railway entirely upon transverse sleepers, a form as would expose the largest amount of bearing surface for the rtion of timber; that the bulk of the ballast should be beneath the of the sleeper, where alone it is useful; to use only the best foreign , to have the rails rolled uniform and sufficiently heavy; the chairs

simple in form, possessing great regularity, and giving the inward inclinatio to the rail within the chairs, instead of depending upon the rail layer doing

Joint Chair. *Intermediate Chair.*



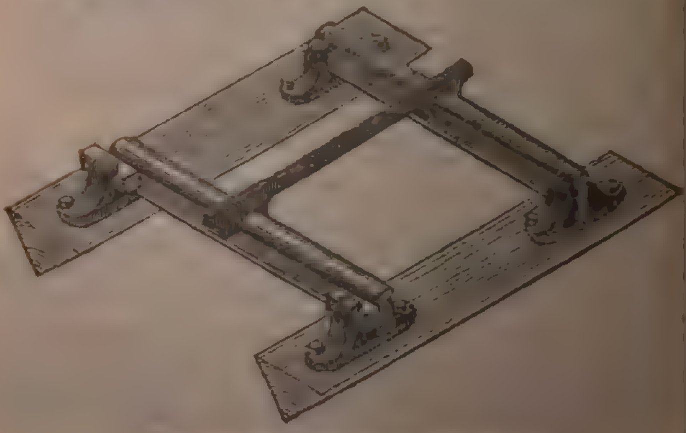
End elevation. *End elevation.*



Plan. *Plan.*

when fixing them on to the sleepers; and that the fastenings should be simple but firm, and not liable to breakage, or to be detached by the passage of th carriages.

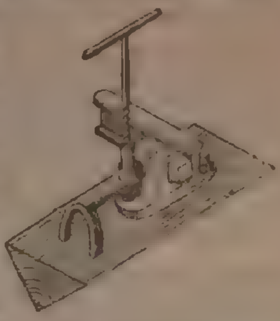
With these views he had directed four sleepers to be cut out of each equa log of foreign timber, giving about 2¼ cubic feet to each sleeper, to pla with the right angle downwards, so that the ballast could always be consolidat



Rails, Chairs, and Sleepers, with the cramp gauge fixed.

ning, without lifting the sleeper, or digging around it, as with square, r formed sleepers; two places are planed to receive the chairs, and one g-hole bored in each sleeper: they are then Kyanised in close tanks, tely filled with the prepared solution, under a pressure of 80 lbs. per inch. When placed upon the ballast, the joint chairs are first put down apart, and the intermediate chairs three feet apart; "cramp gauges" ing the inside and outside of the rails, are then fixed between each pair pers, and the wedges along one side driven up—one treenail being driven chair, the hole for which is previously bored in the sleepers by a gauge, e an equal projection on each side of the rail.

guide tube' of an internal bore to fit the spiral auger for boring the treenail with the external lip tapered to correspond with the hole in the chair for d of the treenail, is then used, and by ry the holes are pierced with great cy, concentric with the hole in the at the same time protecting the tool being injured by the cast-iron. The diate chairs are then fixed in the manner, and the operations are repeat- the opposite rails; the ballast is then dated by ramming. In this manner rk proceeds very rapidly; the ballast ts the sleepers throughout, and has no ncy to fall away from them, the water away freely, and the passage of the waggons (though without springs) he new made portion of the line was to be productive of benefit, rather than



Guide Tube, and Spiral Auger, in use.

inclination of the rail being given by the shape of the chair, insures so accuracy, that after one day's traffic over it, the surface of the rail is d equally throughout, and not alternately on either side, as is commonly se.

uniformity of surface produced is, we think, in a great measure due to rpassing excellence of Messrs. Ransome & May's castings, which appear executed in the highest style of the foundry art, presenting externally a finished appearance; and the dye-like accuracy of their internal form is ed by the introduction of nicely fitted metallic cores. Mr. Pope describes de adopted by the patentees of casting these chairs to be "by placing an plate on each side of the pattern, ramming them up in sand and using an core, which being sustained in its position by a projecting tongue falling groove in the side plates, preserves an uniform inclination of the rails in hairs." Extraordinary precision is thus obtained, and only about 2 per cent. aste castings are made, although they are subjected to a rigid test; for if earing points allow the rails to vary 1-16th of an inch from the required ation, they are broken up. The iron cores do not unduly chill the metal, the average strength is retained. The iron used is chiefly "Welsh Cold ."

e peculiarity of the system of the compressed wooden wedges and treenails nings to railways consists (as explained by Mr. May) in subjecting the of the timber to compression equally from the circumference to the centre. pieces of wood for the wedges are cut out with parallel sides, and forced draulic presses into tapering moulds; whilst in those moulds they are cted to the action of heat, applied through the medium of low pressure , after being allowed to cool, they are forced out of the moulds, and so as they are kept dry they retain their compressed form; but as the operation ly contracts the dimensions of the sap vessels without crushing the fibre, power of capillary attraction is not destroyed, and when the wedge is driven the chair and exposed to moisture they swell so as to become and remain

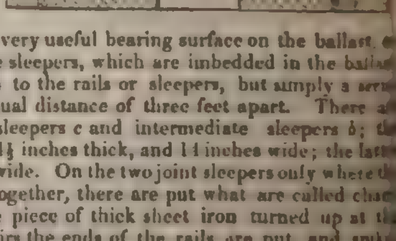
perfectly tight. There is this difference between wedges so compressed and all others; that a true wedge is obtained from a piece of wood cut parallel on all sides, whilst all former modes produced not wedges but parallel pieces.

The diminution of the bulk of the treenails by this process of compression, is from 100 to 63, and of the wedges from 100 to 80. It is found that the wood does not swell until it is placed in a damp situation, as in the sleepers. Even the most solid woods, such as African teak, can be compressed without sustaining injury. Perfectly seasoned timber will not shrink after compression, but green wood will shrink after the process. One of the principal advantages of the compressed treenails is the firmness with which they hold into the sleepers. Around the iron spikes generally used, a sheath of rust is formed by the damp sleeper; the shaking of the carriages tends to draw them upwards; and the elasticity of the fibre around the hole in the sleeper being impaired, it is of no use to drive them down again in the same place, and the chairs eventually become loose.

It is proper to add that Mr. Cubitt disclaims the invention of the angular formed sleeper, as Mr. Reynolds used it before him for his longitudinal bearing rails; but he believes transverse sleepers of that form had not been used previously.

Uncompressed treenails for fastening down the chairs to the sleepers were used in the Hull and Selby railway; in the Dublin and Drogheda and many other lines; and it is well known that these frequently become loose. Yet the difference in the cost between these and Messrs. Ransome & May's must be so trifling as not to be worth a moment's consideration, when compared with the advantages of the latter.

Brighton and Hastings Permanent Way.—The sectional form of railway bars are now for the most part much alike; and similar to that previously described as appertaining to the South-Eastern line: the variations consisting only in some slight differences in the proportions or curves. The only marked distinction which has fallen under our observation is the form employed on the Great Western, the London and Brighton, and a few other lines. This form may be described as a regular four-sided prism with a flange on two opposite sides for bolting it down to the sleepers or other supports, an illustration of which is afforded by the following cut, which is explanatory of the permanent way of the Brighton and Hastings Railway.

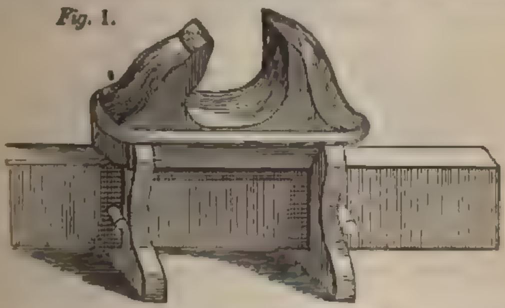


The marginal figure represents the rail in section; it is drawn to a scale of four inches to the foot, from which it appears by calculation to weigh about 80lbs. per yard: affording that degree of strength and stability which the present experience of railway engineers has dictated the necessity of. There is considerable stiffness in this configuration. Over the flanges it is fully six inches wide, and affords thereby a very useful bearing surface on the ballast, on which it is supported, except at the sleepers, which are imbedded in the ballast. There are no longitudinal bearings to the rails or sleepers, but simply a series of transverse sleepers *b c* at the usual distance of three feet apart. There are two sorts of sleepers used, joint sleepers *c* and intermediate sleepers *b*; the former are Baltic deals 8 feet long, 4½ inches thick, and 11 inches wide; the latter 8 feet long, 4½ inches thick, and 9½ wide. On the two joint sleepers only where the ends of the rails *a a* are brought together, there are put what are called chairs *d d*, consisting merely of a square piece of thick sheet iron turned up at the edges thus ⌴. Into these chairs the ends of the rails are put, and spikes driven through all three; namely, the flanges of the rail, the "chair," and the joint sleeper. Between every two joint sleepers there are usually three intermediate sleepers *b*, and to these the rail is fastened by a half-headed spike

(shown at *e*) not through holes made in the flanges, but so that the overhanging half-head shall just clip over the edges of the flanges. How such a structure can be expected to last for a month, under the ordinary strains and concussions of railway traffic, is to us a matter of surprise.

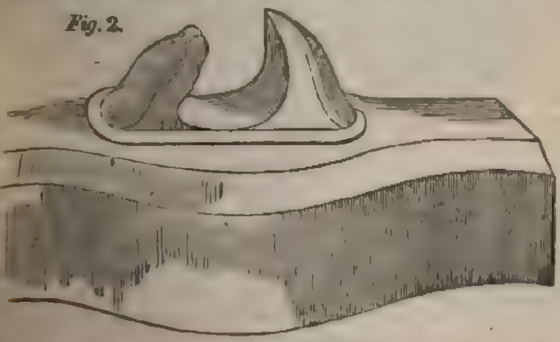
Orsi's Patent Chairs and Sleepers—Mr. Orsi's patented improvements in sleepers and blocks for supporting the rails consist in forming the sleepers of metal, imbedded in cement or other plastic material, so as to defend the metal from the action of the air and moisture; and afford a large bearing surface. *Fig.* 1

Fig. 1.



represents perspectively a cast-iron chair to which is cast on the under side a pair of lugs, having a large rectangular aperture in each, through which is passed a bar, and fastened thereto by the two pins shown. The bar is a substitute for an ordinary transverse sleeper, and the two chairs are thus fixed at the required gauge apart with great facility and truth, and possess great firmness and durability. After the chairs and bars have been thus united they are to be imbedded in a bituminous cement up to the lower side of the chairs. In the annexed *Fig.* 2 one of a pair of chairs is shown so imbedded in cement; the other chair of the pair being supposed to be connected with it on the left

Fig. 2.

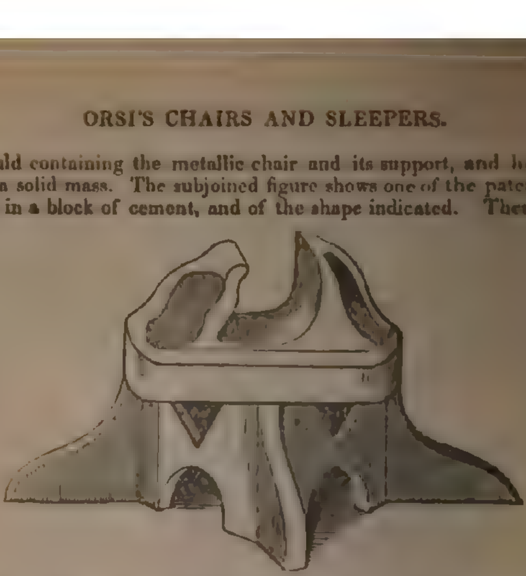


hand side; the union being effected by what may be termed a metallic sleeper, rendered indestructible by its bituminous encasement.

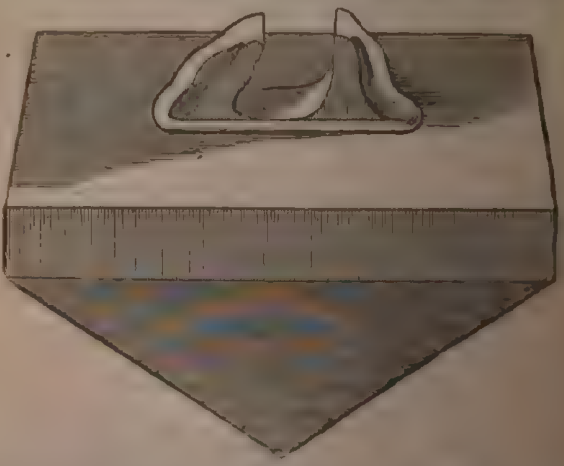
Sleepers or blocks formed of cement, carrying the chairs so braced together, are intended to be placed transversely at suitable distances apart, along the line of the intended railway; and when they are firmly secured to the ground, the rails are to be fixed to the chairs in the ordinary way.

In the following engraving is represented one of Mr. Orsi's chairs, which is cast in one piece with the winged and other projections shown. This is intended to be imbedded in asphalte or other cement, so as to form a block sleeper with a broad incorrodible base. The cement in a fluid state is poured

into a mould containing the metallic chair and its support, and harde
cools into a solid mass. The subjoined figure shows one of the patentee's
imbedded in a block of cement, and of the shape indicated. These ex



of Mr. Orsi's invention will suffice to give an idea of the modifications w
it is susceptible of when taken in conjunction with the following summary

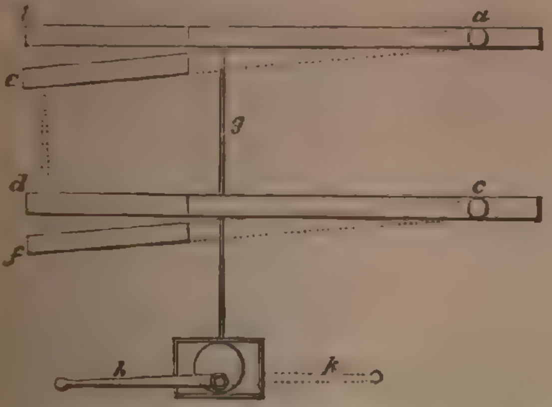


claims made in the specification, which are expressed as follow.

"*Firstly*, constructing the sleepers of bars or rods of metal, which are p
through the under part of the railway chairs, and are imbedded in cemen
as to form blocks, having broad surfaces at bottom; and also the pe
construction of chair for embracing or holding the bars or rods, as a
described and shown in the drawing. *Secondly*, imbedding in cement
of wood braced by transverse tension rods, so as to form sleepers, upon w
the ordinary chairs for railways may be fixed by bolts, screws or nails. *T*
fixing chairs for railways in blocks of cement to form sleepers, by imbe
projections or wings at the lower parts of such chairs in the plastic ma
connecting two such blocks or sleepers together by transverse rods, attac
the metal chairs. And *lastly*, constructing longitudinal sleepers for ra
by means of stout planks of wood, combined with iron bars or rods, p
side by side, and imbedded in cement so as to form a continuous block,
which the rails may be fastened down, without employing chairs."

Switches.—In order to enable railway trains to pass from one line of rails to another as becomes necessary on various occasions, at certain parts of the line small portions of the rail are formed of bars, termed switches, which are moveable upon a pivot at one end of the bar. Various arrangements of switches have been proposed, or are in operation, depending partly on the nature of the service for which they are required, some of which are self-acting, and others require to be moved by an attendant.

The annexed figure represents a mode of passing carriages from one line of road to another, adopted by Mr. Stephenson, on the Liverpool & Manchester Railway, and described in Wood's Treatise on Railways.



Let *e f* be the road into which the carriages are to be made to pass. *a b c d* being the main line of road, two rails are made moveable upon the joints *a* and *c*. these two rails are joined together at the other end by an iron rod, which is extended to one side of the road. This end of the rod is terminated by an oblong box, as shown in the figure, and within this box an eccentric cam or wheel is placed with an upright axle, on which is fixed the handle *h*. The difference between the radii of this wheel from the centre of motion, is precisely equal to the distance between the ends of the two rails; when, therefore, the eccentric wheel is in the position shown in the figure, the carriages will pass along the main line: but on turning the handle round to *k*, and with it the eccentric wheel, the latter pushes the rod and rails into the position shown by the dotted lines. This mode of turning the carriages into another road is quite safe, and can admit of no mistake if the handle be turned sufficiently round, as the eccentric wheel is made to move it the proper distance and no farther.

Curtis's Patent Switches.—Mr. W. J. Curtis's improvements in switches are come into extensive use on the Great Western, South Western, Midland Counties, and other railways.

Fig. 1, in page 428, shows a plan of switches for a single crossing. The switches may be formed various ways, but the patentee recommends the following; viz. rivetting the bars, whether two or more, to a flat plate c half an inch thick, 10 or 12 inches wide, and 15 feet long; the bars having a section to correspond with the rails. are rivetted to this plate c; one rail being bent to correspond with the curve or cross line, and the other straight to correspond with the main line (if straight), or should both be curved then both bars are curved to correspond with their respective lines. upon the back or underside the centres r and stud plates o o are rivetted.

The best shape is to make them round, with a flat face or flange, and the ends welded into them. The bed planks A are formed of oak planks 3 inches

thick, and at regular distances the stud plates I I are let into the oak bed p rising about 1-8th of an inch above the surface, so that the iron plat upon the iron surfaces of the stud plates, with less friction than if they

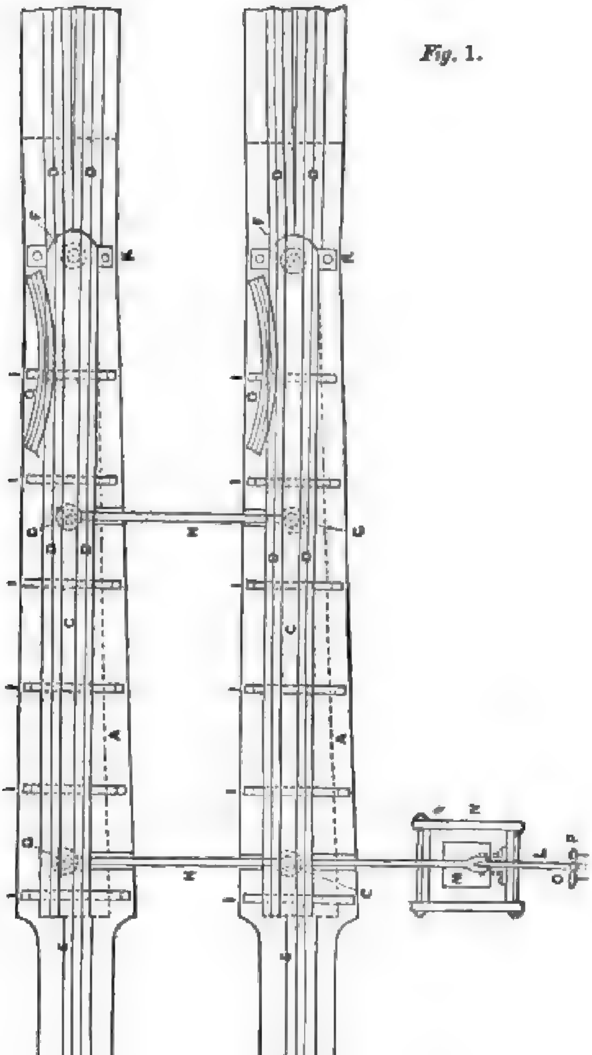


Fig. 1.

level with the timber. Towards each extremity of the stud plates studs are which confine the switches within their limits of motion, and form s against which they rest, and thus acquire a certain degree of solidity the trains pass over them. The oak planks are then let into the longi

timbers of the railway, if formed upon that plan, or bolted to timber of sufficient solidity and united in the usual way with the rails, if the system of stone blocks and iron chairs be employed. A plate K forms the centre plate for the centre studs to work in; a hole is bored in it to suit the pin, and it is then bolted to the bed planks, and thus the switches are secured at the end. Two radius bars H H, connect the switches in the usual manner, the longer rod passes to the lever L, by which the movement of the switch is effected; the lever L shown in the plan, acts in the manner of a treadle, and the upright bar O, as a string or holding bar: thus, a man depresses the end of the lever L, by pressing his foot upon the flat part X, and laying hold by the cross head P, of the upright bar O, he exerts a force as if he were lifting a weight, by which means his weight and muscular force are brought into action at the same time, and he is able to lift the counterbalance weight M of nearly three hundred weight with great ease: thus a very heavy counterbalance weight may be employed to keep the switch open. The upright bar O is flexible, and formed like a spring, with a notch or stud which shuts under the lower side of the lever L when the switch is open, or right for the line, and prevents the possibility of the train opening it as it passes over it; the counterbalance weight is enclosed in the usual way, in the ground box N. D D D D, are the rails of the line, and the cross line at the head of the switch, and E E the rails at the foot of the switch. The oak bed planks are made long enough so that about 18 inches or two feet of the rails at each end lie upon it; thus making the whole steady and secure. A hand lever may be employed instead of the treadle, or any other suitable means to work the switch; also if the crossing be a compound one, or any number of turn-outs take place from one line, then each plate has rivetted to it as many bars as there are separate lines, and each bar must be bent or otherwise as before explained.

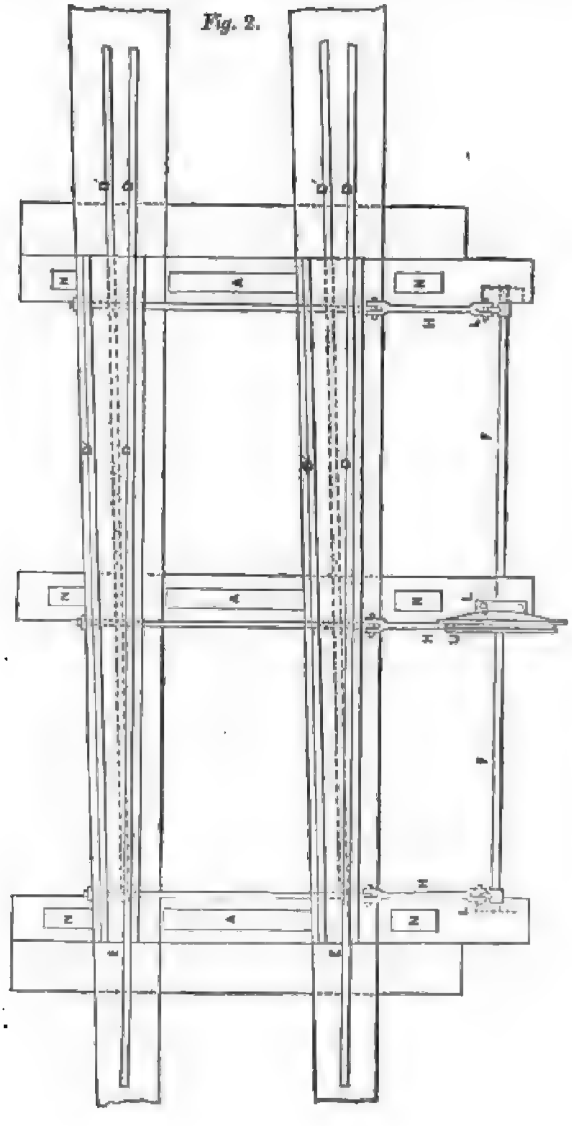
The safety-guard rail Q shown in the figures, is contrived with the view of preventing an engine or train running off the rails, by the switches being placed wrong. As has been before observed, the balance weight keeps the switch right for the line, but whilst right for the line it is wrong for the cross line; in this case, if an engine were to pass along the switch of the cross, the wheel would impinge against the guard rail Q, push the switch over, and make it right for that line, and when it is passed over, the switch will shut again by the reaction of the counterbalance, and keep it right for the main line as before stated.

Fig. 2, in page 430, shows a modification of these switches: the main features of this arrangement are the same as those of the former one, the bars being bent to the curves of the respective lines to which they belong, and the same clearance spaces left; the principal difference between the two is that in the latter case the switch has a movement transversely to the line, and not moving from a centre as before: the bars are bolted to a cross frame of timber A, held together by bolts passing through the frame, and the transverse movement of the frame is produced by the levers L L L, fixed upon the lying shaft F; to these levers are attached the connecting links H H H, connected with joints fixed in the transverse frame; then by moving the long hand lever L L, either of the bars of the switches is brought in contact with the main or cross lines at will: stopping pieces N N N are placed to confine the movement of the switch as in the case of *Fig.* 1. M is a cast-iron standard for the lever to work against, and holes are made in the segment for a pin to be inserted, to confine the lever in the usual way. D D D′ D″ are the bars of the switches, D D D′ D′ the bars of the line and cross line, and E E the bars of the line at the foot of switch.

Fig. 3, in page 431, represents an adaptation of these switches to points of crossings. The switches are made in the same way as those previously described, except that they are shorter, the length whatever it may be being determined by the distance for clearance between the rails which may be fixed upon by the engineer, and for which 3 inches will be generally found to be sufficient. The point of contact for the foot of the switch, may be at the point where the inner edges intersect each other, or at any place between that point where the outer edges of the rails intersect each other; then measure from this point until the rails open 3 inches (or the space required for

clearance) which gives the place for the head or centre end of the swi stud or joggle pieces are placed as before described, to confine the swi within their limits of motion. The switches may be either double or sin and accordingly one is shown as single, and the other as double in the fig but in all cases the head or centre of the switch should be placed as show this figure, because whichever way the switch is laid, it is held in its plac the fixed stud pieces I I, so that a train passing over the switches, has a tend by its action to push the rails out to keep the switches the more st

Fig. 2.



onnecting link worked l crank M, which crank mnected with a lever, t, or eccentric by means nk N: the rod slides ie guides F F F F which he purpose of the es and glands: these ces as well as the tes are fixed in any cure, and suitable By the movement of rank, the connecting moved towards the d, and the rods E E to occupy the position by the dotted lines: ies are then thrown rith the other or cross

in page 432, re- n plan these switches to form the points of crossing, where M M main lines, and Y Y f cross lines, and H H ir of cross lines. The ns of the cross lines by the dotted lines; bars D D alternately connexion with Y Y : the switches are the same way as ore described, and tud pieces I I I I, are o limit the motion of es as before described. he circular case in upright shaft of rank or lever works. lower end of the aft a three-pronged rmed, and to one of ıks or prongs the link H is united oint; each of these ches into the latch E, es over it, so that entre prong is held ch as shown in the main line M M is s drawn, but when is moved to the one ie other, and the e to complete either lines Y or H, then the F G H is held in the etains the switch in . The latch E is by a man placing

Fig. 3.

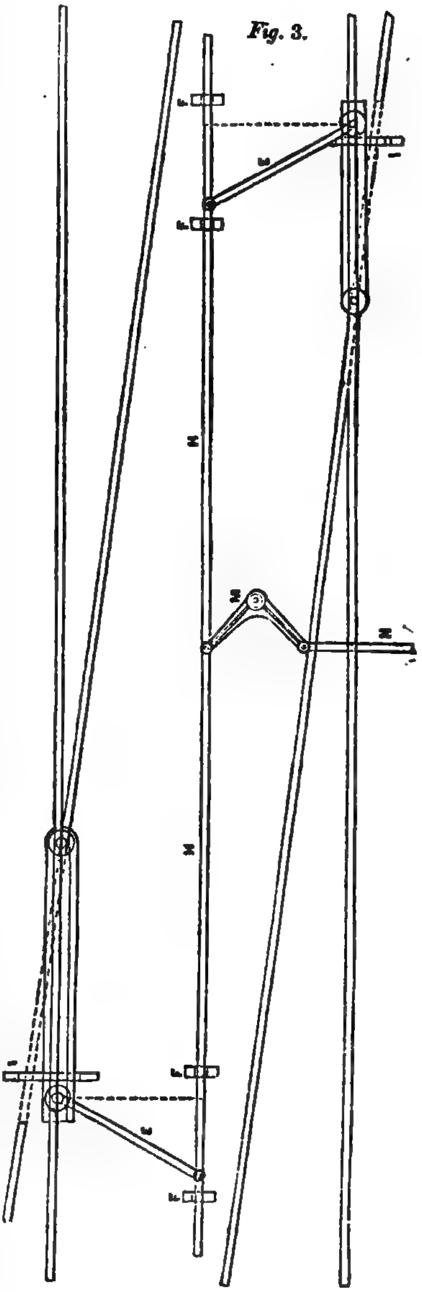
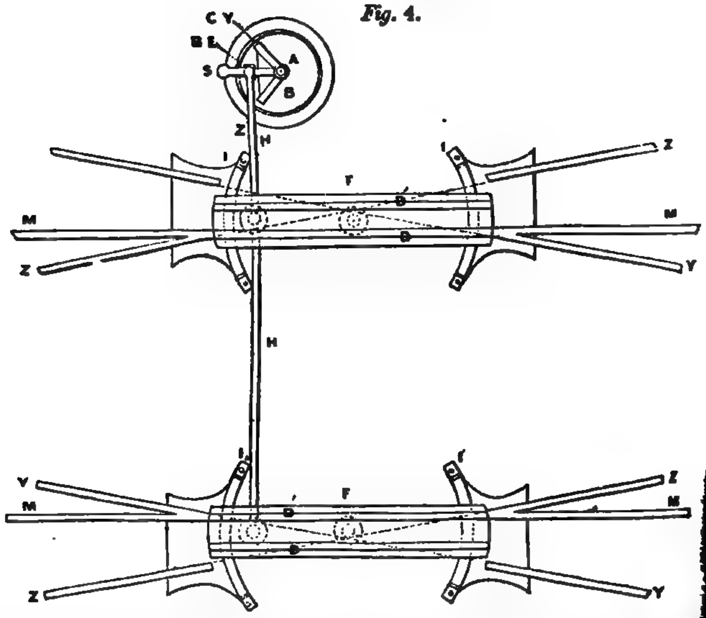


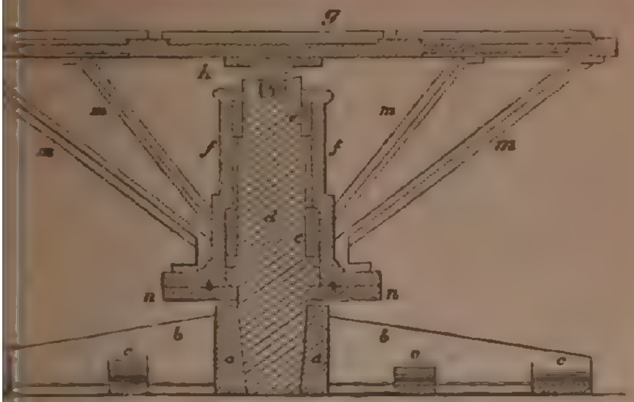
Fig. 4.



his foot upon the spring S, which when released raises the latch again: the rods H H connect the switches together, and the switches are based upon timber as before described, or are placed in a cast-iron bed-plate, or finished in any other usual and suitable manner. The centre studs F F work in cast-iron bed-plates.

Turntables.—In order to transfer an engine or carriage laterally to another line of rails, at a station or terminus, circular platforms called turntables are established upon each set of rails, which turn as upon a pivot in the centre of each line, each contiguous pair of tables being connected by short branch rails, standing at right angles to the line of rails. The engine or carriage to be transferred is brought to rest wholly upon one table, which is then turned a quarter round, and the carriage is then wheeled on to the next turn-table, which being likewise turned a quarter round, the engine or carriage will then be in a position to proceed on the line to which the second table appertains. Turntables are variously constructed; the annexed figure (p. 433) represents a section of one which is in pretty extensive use on several railways; amongst others (we believe) the Great Western.

It is the invention of Capt. Handcock of Birmingham, who obtained a patent for it in 1840. The base plate is formed of cast iron, and consists of a deep socket *a* in the centre, from which branch several radiating ribs *b b*, which are braced together by two broad flat rings *c c*; *d* is a column or pedestal firmly keyed into the socket in a perfectly vertical position, and froming the support to the platform of the table; *e e* are loose collars of gun-metal, resting upon shoulders formed on the pedestal, which is accurately turned at those parts so as to fit the collars without shake or friction; *f* is a cylindrical tube or casing surrounding the pedestal, and collars with recesses accurately bored to fit the collars; *g* is the turning platform, having in its centre on the under side a steel pivot *h*, which rests in a steel step *k*; in the top of the pedestal *m m* are a series of struts or stays, resting upon a stout flange at the bottom of the casing *f*, and supporting the platform at the circumference. To provide for the efficient lubrication of the collars, a flat plate *n* having



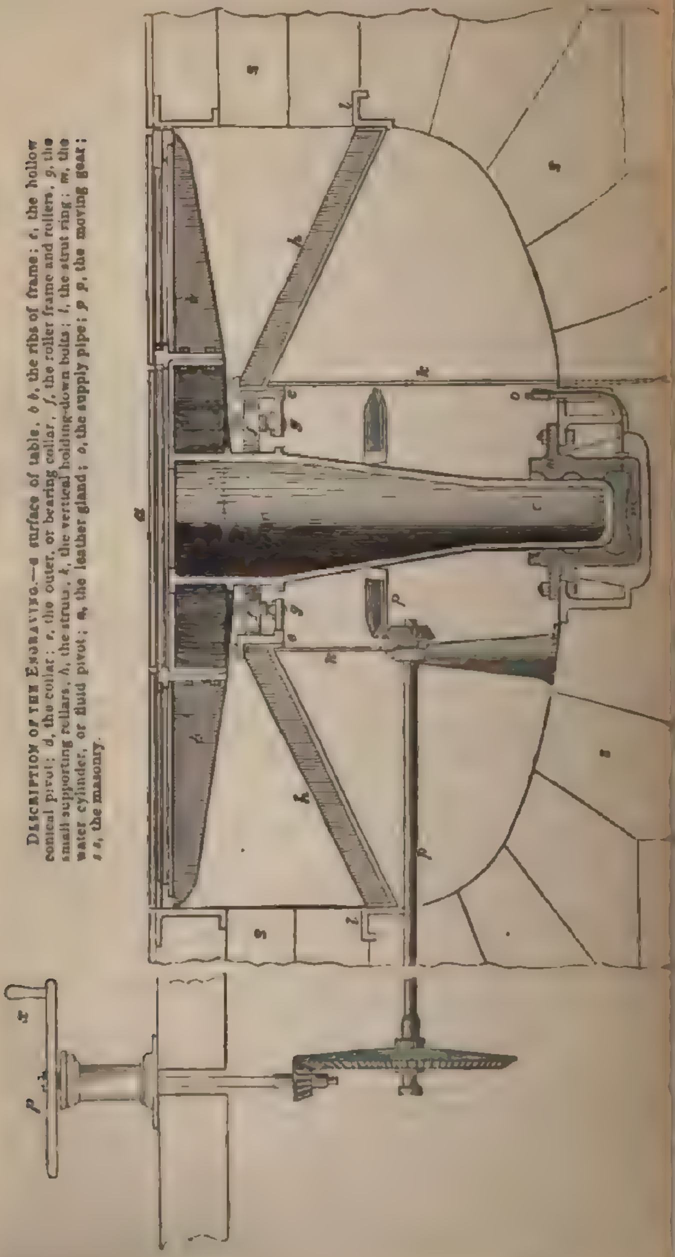
...ings covered with leather to form a tight joint, is screwed up to the ... the flanch of the casing, and the space between the pedestal and ... of the casing is filled with oil. The following cut (page 434) repre... ...ntable of a different description, which was invented by Mr. Robert ... Dublin, C.E.; from whose able pen an ample description of it ... the Mechanics' Magazine; we shall, however, endeavour to explain ...uction in a more concise manner.

...he vertical pressure of the table being supported on a fluid, Mr. Mallet ... the "Hydrostatic Turntable."

...atform *a* of this table is much the same as usual, consisting of ...ore interlacing ribs *b*, of about 12 inches in depth, at the centre, ... by a ring at the circumference, and all cast in one piece. The tops ... carry the crossing rails, and the interspaces are planked, or open ...trellis gratings are dropped into them and rest upon a rebate. The ...rtion of the ribs is secured by bolts to the projecting flanches of the ...tical pillar or pivot *c*, upon and with which the whole revolves. ... portion of this pivot, as well as a broad collar, or neck *d*, close under ...rm, are turned truly cylindrical, while the form of the remainder is ... conical.

...tral pillar, or pivot, is cast hollow, of thickness suitable for sufficient ... At the same level, and concentric with the turned collar *d* of the ... placed a cast-iron bored ring *e*, considerably larger in internal ... than the external diameter of the pivot, and which is sustained in its ... all lateral or other motion thereof prevented, by a number of ...struts *h*, and by four vertical bolts *k*, fitted and bolted to the outside ...g, or "bearing collar" *e*, and also to a large concentric ring casting *l*, ...uilt into the side walls of the turntable pit.

...wer part of the main pivot consists of a turned cylinder, like the ... ram of an hydraulic press, and which, also, like the latter, drops ...rong bored cylinder *m*, of a few inches in length, prepared at its ... to receive a double leather collar *n*, upon Bramah's plan, so as to ...ater-tight under considerable pressure; the cylinder has a close ...nd is provided with a small tube *o*, opening into one side, and closed by ...lug valve of simple construction, by which the interior of the cylinder ...filled with water. The lower part of the turntable pit consists of an ...rch, or rather dome, of brick or stone, resting upon a bed of concrete ...site, and this small hydraulic cylinder is bedded down upon a cast- ... forming the centre or crown of the inverted dome, and is secured ...ted to the latter by means of bolts passing through a projecting ... round it. To counteract the lateral pressure, when an engine is ... to the table, is the object of the upper collar *d*, and bearing collar *e*;



DESCRIPTION OF THE ENGRAVING.—*a* surface of table; *b b*, the ribs of frame; *c*, the hollow conical pivot; *d*, the collar; *e*, the outer, or bearing collar; *f*, the roller frame and rollers; *g*, the small supporting collars; *h*, the struts; *k*, the vertical holding-down bolts; *l*, the strut ring; *m*, the water cylinder, or fluid pivot; *n*, the leather gland; *o*, the supply pipe; *p p*, the moving gear; *s s*, the masonry.

...een these, into the annular space, left by reason of their different diameters, ...opped a circular wrought-iron frame *f*, consisting of two rings of flat bar ...carrying six turned cast-iron rollers, revolving horizontally between these ...s, upon wrought-iron pins, which pass through and connect both wrought-...rings. The weight of these rollers and rings is sustained by four small ...s *g*, which are fixed as to position, and revolve vertically in pairs, cast in ...ets, projecting inwardly from the turned bearing collar.

...*Broad and Narrow Gauges.*—The inconvenience arising from a diversity ...e breadth of space between the two lines of rails, on one railway compared ...that on another, became the subject of much discussion, and of animad-...on upon Mr. Brunel's adoption of the "broad" gauge of 7 feet, on the ...Western line, in preference to the previous generally adopted "narrow" ...e of 4 feet 8½ inches, between the rails. The inconvenience is especially ...n the transfer of many kinds of goods, where the "breaks" of gauge ..., as it necessitates the unloading the waggons on one line, and reloading ...waggons on the other line; and as they are of very different dimensions, ...equire a different plan of loading, injury often results by the shifting and ...king of the goods; besides incurring much labour, expense, loss of time, ...not unfrequently pilfering. A great variety of mechanical contrivances ...been, for years past, suggested to remedy the inconvenience of the change ...uge, but none that can be regarded as equalling the advantages gained by ...interrupted or uniform gauge.

...determine what ought to be done under these difficulties, a government ...ission has been appointed to inquire "whether in future acts of ...ment for the construction of railways, provision ought to be made for ...ng a uniform gauge, and whether it would be expedient and practicable ...e measures to bring the railways already constructed, or in progress of ...uction, in Great Britain, into uniformity of gauge, and to inquire whether ...ther mode could be adopted of obviating or mitigating the evils apprehended ...ly to arise from the break that will occur in railway communication, ...the want of an uniform gauge." The commission was dated 11 July, 1845, ...consisted of the following members: Sir J. M. Frederick Smith, Lieu-...t-Colonel Royal Engineers, Professor Airy, Astronomer Royal, and ...ssor Barlow; names in which the public deservedly place the highest ...dence for their intellectual capabilities and perfect integrity.

...ese gentlemen called before them such persons as they deemed most ...etent by their situation, knowledge, or experience, to afford them correct ...mation on the subject of their inquiry, and had produced before them such ...s and documents from the various railway companies as appeared to be the ...calculated to aid their researches. They personally examined into the ...course of proceeding on various railways, both at home and abroad, ...ally those which are incident to a break of gauge. Having inspected ...l locomotive engines, as well as various mechanical contrivances, invented ...r for the general use of railways, or for obviating the special difficulties ...ed to arise from the break of gauge, and having carried their investi-...s to the utmost useful limits, they drew up a Report, which we shall now ...ed to give the substance of, in a condensed form; as all the material facts ...g upon the subject seem to have been investigated with scientific ...gence, and correct judgment, and entirely free from party bias to any of ...reat rival companies, whose interests are affected by the decision of the ...on propounded; moreover, because many of their deductions from the ...ce elicited, form useful data for the guidance of railway engineers.

...attention of the commissioners was first directed to ascertain whether ...eak of gauge could be justly considered so great an inconvenience as ...quire the interference of the legislature. This important part of the ...y is treated under the following heads; viz. *first*, as applying to fast or ...r trains; *secondly*, as applying to ordinary or mixed trains; *thirdly*, to ...trains; and *fourthly*, to the conveyance of troops.

1. *As applying to Fast or Express Trains;* the commissioners observe, "We believe that the inconvenience produced by a break of gauge will, in some respects, be less felt in these than in other trains, because the passengers travelling by fast trains are usually of a class who readily submit to many inconveniences for the sake of increased speed on the journey; the inconveniences of a break of gauge are reduced, in this instance, to the removal of the passengers and a moderate quantity of luggage."

2. *As applying to ordinary or mixed Trains.*—"In these trains the passengers considerably exceed in number those who travel by the fast trains, and they have generally a much greater quantity of luggage. To such travellers a change of carriage is really a serious inconvenience, and it is a well-known fact that persons travelling by railways in communication with each other, but under different managements, endeavour to make such arrangements as to admit of their travelling by those trains which afford them the accommodation of occupying the same carriage from the beginning to the end of their journey.

"The managers and directors of railways are well aware of this feeling, and in some instances accommodate the public by enabling travellers to avoid a change of carriage on the journey.

"It is by the ordinary or mixed trains that private carriages and horses are conveyed, and the removal of either from one truck or horse-box to another, at any part of the journey, would be attended with inconvenience and delay; and with regard to the horses, it would involve considerable risk.

"We arrive, therefore, at the conclusion, that the break of gauge would inflict considerable inconvenience on travellers by the trains now under consideration.

"The change of carriages, horse-boxes, and trucks, and the transference of luggage of an entire train of much extent, must, even in the day-time, be an inconvenience of a very serious nature, but at night it would be an intolerable evil, and we think legislative interference is called for to remove or mitigate such an evil."

3. *As applying to Goods Trains.*—"From the statements made to us by carriers on railways, and from our own observation, we are induced to believe, that not only a considerable degree of care, judgment, and experience is necessary in the stowage of merchandise in railway waggons, but also, that it is desirable that when properly packed the articles should, generally speaking, not be disturbed until the journey is completed. We find that in the arrangement of merchandise, the heavier goods are placed at the bottom, and the lighter at the top of the load, and so secured as to prevent friction as far as practicable from the jolting of the waggons; and it is considered very desirable with a view to prevent loss by pilfering, that the sheeting, which is placed over the load, should not be removed till the completion of the journey. Indeed, acting upon this principle, carriers find it profitable to send their waggons partially filled from various stations on the line, thereby increasing their toll to the railway company, rather than incur the risk of loss by theft, to which they would be exposed by uncovering the waggons on the journey, to fill up with intermediate local goods waggons that may have started with light loads from one of the termini.

"In the conveyance of machinery and articles of a similar class, which are both heavy and delicate, it is of the utmost consequence that the load should not be disturbed between the beginning and the end of the journey. The traffic upon the line of railway between Birmingham and Bristol has been greatly restricted by the interruption of gauge at Gloucester.

"In respect to the conveyance of minerals, the inconvenience of a break of gauge would be very serious; the expense of the transfer would be sensibly felt; moreover, many descriptions of coal are subject to great deterioration by breakage.

"In regard to various articles of agricultural produce, the loss by removal would be less than on other classes of goods; much inconvenience, however, would be found in the transfer of timber; and the difficulty of shifting cattle, would be so great as to present an insurmountable obstacle to such an arrangement from the excited state of the animals after travelling by railway, and the

they in consequence offer when it is attempted a second time to force a railway waggon."

plying to the Conveyance of Troops.—"This is another use of railways have deemed it necessary to consider. Although a break of gauge of route would produce both delay and confusion, yet, as it is practicable to give notice of the intended movements of a body of inconvenience of the break of gauge might be so reduced, as not to of great importance; but in the event of operations for defensive against an enemy, the inconvenience would assume a serious character. ld appear, that, for the defence of the coast, the proper course would the great mass of troops in the interior of the country, to wait until selected by the enemy for his attack should be ascertained with nd then to move upon that point such an overwhelming force as adequate to the emergency.

ops should be carried with their equipments complete in all their with their artillery and ammunition; and it therefore appears in- necessary, in order to insure the requisite supply of carriages, ps little or no notice can be previously given, that the whole should ed in the same vehicles from the beginning to the end of the

sidering the subject in several other points of view, which it would to specify, the commissioners came to the conclusion that *a break uld be a very serious evil.*

of Telescopic A les to apply to all gauges.—Of the various contrivances submitted to the investigation of the commissioners, der the foregoing denomination; wherein the running wheels of the re made capable of sliding along the axles when required, per- wheels to approach nearer to, or separate further from each other, be applicable to both gauges. By detaching the wheels from one then pushing the carriage along converging, or diverging rails, eels were brought to fit the change of gauge, and screwing the he axles again at another fixed point, the required alteration would be easily managed, but it is nevertheless liable to serious objections. nown that a very slight degree of unsteadiness of the wheels of a rriage upon the axles, renders it liable to run off the rails. The entire train might thus be endangered, by one case of neglect in the wheels of a carriage; and when it is considered that the would have to adjust a great many carriages in succession, some- ny as a hundred in one goods train; that the adjustments have ade hurriedly; occasionally in the worst of weather, and at night; attention required for loading or unloading of goods; altogether, ome so severe and anxious a duty to the attendants that it would be sible to avoid the occurrence of very serious accidents from over- t, or forgetfulness. But the danger attending the plan is not the on. On the ground of expense, the introduction of the plan is

of mounting Carriages upon Trucks of a different gauge.— running loaded waggons from a narrow gauge railway, on to trucks the broad gauge lines, is of course one of facility; but it is only for the transmission of goods from the narrow to the broad gauge. to carry loaded broad gauge waggons upon trucks on the narrow would be preposterous, as it would necessitate all the broad gauge provided not only with their large trucks, but a stock of narrow ons, or they would be unable to transfer the goods on to the narrow except occasionally. But even with regard to the passage from the he broad gauge, the system will not bear examination. "If the pported on springs, there is practically a difficulty in running the

waggons upon them; and if they are not supported on springs, they will sustain great injury on the journeys. If they are loaded singly, there will be a great delay; if they are placed in a row, and the narrow gauge carriages are run through the whole series, very great caution will be necessary to secure each carriage both in front and in rear." For the foregoing as well as other considerations, the commissioners reject the proposal as entirely inapplicable to the traffic of railways.

Expedient of shifting the bodies of Carriages from one wheeled platform to another having a different gauge.—Although the system has been partially adopted in France, of shifting the bodies of carriages from the road wheels to those of the railway, the commissioners regard it as inapplicable to our rapid travelling; while it deprives the railway system of one of its greatest conveniences, namely, "its readiness to receive almost any number of passengers without warning, and to carry them to any required distance."

Expedient of carrying minerals and merchandise in loose boxes, capable of being shifted from one Truck to another, in such manner that one may be carried on a narrow gauge, and two on a broad gauge truck.—The commissioners state that this plan has been repeatedly tried, and the experience is that it has barely succeeded in a temporary trial by one engineer who had the entire control; but that it has in most instances failed, owing to the deterioration produced by the shifting of the mineral conveyed; though no expense was spared in the erection of proper machinery for effecting the transference of the loose boxes; and these failures occurred in a traffic which is comparatively regular, namely, that of coal. In traffic of a more varied character, the liability to failure would be much increased.

Expedient for a Combination of two gauges on one line, by placing one or two intermediate rails between those on the broad gauge, so as to enable the use of the engines and carriages of both gauges, would also be productive of many difficulties, and the expense be enormous. If two rails were placed between those of the broad gauge, so as to form a narrow gauge track, the carriages of each gauge might travel together, without any alteration of their buffers, as the distance of these from the centre is precisely the same in both. The cost of such an alteration has been estimated at even more than entire change of gauge, including engines, and carrying stock. The complication which it would introduce at the crossings would be attended with increased danger, or a loss of speed. It would also be difficult to pack and adjust such rails properly. In the case of a single rail being inserted at 4ft. 8½in. distance from one of those on the broad gauge, the difficulties just mentioned would be in a certain degree lessened, but it would introduce another, which seems to have escaped the attention of the commissioners; namely, that of causing the double traffic upon only one of the original broad gauge rails, and the single traffic on the other broad gauge rail. If we consider the enormous difference between the operating forces on the rails in a double train, the effect of the concussions of such an unbalanced force would be rapidly destructive of far more stable substructures than have hitherto been found necessary. It would at least render it necessary to make the single rail which sustains the double traffic much stiffer, and the supports more solid; otherwise a disruption would speedily ensue, and it would always be dangerous to travel upon. Besides, the narrow gauge traffic on the broad gauge line would probably continually increase, and thereby increase the disparity of the resisting powers of each rail, and never attain that uniformity of vibration and resistance, that appears to be essential to the stability of the structure.

The commissioners lay it down as the first principle, that intercommunication of railways throughout the country ought, if possible, to be secured. If, to obtain the last-mentioned object, it should be necessary to alter or make a change in any existing railways, they think that it may be left as a matter of

…er consideration for the legislature, whether in these limited instances …mbination of gauges may not be allowed.

…er giving to all the plans submitted to them, the most mature considera- … the commissioners came to the conclusion, that none of them were …ed to effect an adequate remedy for the inconveniences incident to a … of gauge; and hence they entered upon the following

…siderations on the general policy of establishing an uniformity of gauge …ghout the country.—In the earlier period of railway history of this …y, the great trunk-lines were so far separated as to be independent of each … and, as it were, isolated in their respective districts, and no diversity of … was then likely to interfere with the personal convenience, or the …ercial objects of the community; but now that railways are spreading … directions, and becoming interlaced with each other in numerous places, … isolation is removed, that independence has ceased, and the time has …d when, if steps cannot be taken to remove the existing evil of the …ity of gauge, a wider spread of this evil should be prevented. The com- …oners having arrived at the decision that equalization is desirable, they …d to consider what gauge would be the most eligible to adopt, under the …wing four heads:—

…Comparative Safety of the different Gauges.—Experience has shown that … accidents arise from collisions, obstructions on the road, points …ly placed, slips in cuttings, subsidence of embankments, a defective state … permanent way, loss of gauge, broken or loose chairs, fractures of wheels …les, &c., and lastly from engines running off the lines from some other … Of these several causes of accidents, all except the last are obviously …endent of the gauge; and with reference to the last, it does not appear … either of the gauges possesses more security than the other against such …ents. Only six accidents of the kind occurred between October 1840, and … 1845; whereas there have been no less than seven during the last seven …s, and these last are all attributable to excessive speed, the majority … happened to express trains. Of these 13 acidents, 10 have occurred on …rrow gauge, and only three on the broad; but as there are 1901 miles on …rrow gauge, and only 274 on the broad, therefore the comparison per … in favour of the narrow. Nevertheless, as the speed on the Great Western … exceeded that on the narrow lines, some allowance is due on that score. … primary causes of engines getting off the rails appear to be overdriving, …tive road, a bad joint, or a badly balanced engine. If, in consequence …avy rains or other unfavourable circumstances, any part of the road …es unsound, the engine sinks on one side as it passes along such part of …l, suddenly rises again, and is thus thrown into a rocking and lateral …tory motion, with more or less of violence according to the rate of speed; … very similar effect is produced in passing at high speed, from one curve …other of different curvature. A succession of strains is thus thrown upon …ils, and if, before the rocking subsides, the wheel meets with a defective … or rail, which yields to the impulse, the engine and train are thrown off … necessary consequence; but such casualties, as far as we can see, are … liable to happen to both gauges.

…ral differences in the construction of the broad and narrow gauge engines, …gard to their proportions and adjustments of the weight, have been sup- … to operate as a cause of their running off the line. These points have been …gated by the commissioners; but they sum up their remarks on the score …ety by stating,—"Upon the whole, therefore, after the most careful con- …tion of this part of the subject, we feel bound to report, that as regards …fety of the passenger, *no preference is due with well-proportioned engines …r gauge, except perhaps at very high velocities,* where we think a pre- … would be due to the broad gauge." The next question entertained was,

…The relative accommodation and convenience for Passengers and Goods on … Gauge.—The first class carriages of the broad gauge are intended to carr…

eight passengers in each compartment, and the compartments are sometimes divided by a partition and inside door. On the narrow gauge lines, the first class carriages are usually constructed to carry only six passengers in each compartment; and the same width is allowed for each passenger in both gauges. Until recently the broad gauge carriages were altogether more commodious than those on the narrow, but now the first class carriages on the narrow gauge possess equal commodiousness; they are both highly so.

In the second class carriages on the broad gauge, six persons sit side by side, each carriage being capable of holding 72 passengers. On the narrow gauge, generally, only four persons sit side by side, the total number in each carriage being 32. These last are the most comfortable of the two.

With respect to the ease of the carriage, or the smoothness of motion, the evidence taken is conflicting, but the experience of the commissioners led them to consider, that at the higher velocities, the motion is usually smoother on the broad gauge.

With respect to the conveyance of merchandise, such as manufactured goods and their raw materials; mineral products, such as coal, lime, iron and other ores; agricultural produce, such as corn, hops, wool, cattle and timber, the evidence of intelligent persons engaged in the carrying business has been taken, who expressed a strong opinion that the smaller is far the most convenient and economical. Another advantage of the smaller waggons is its economy in lessening the *dead weight*, where full loads cannot be obtained at the stations. Here the dead weight would be greatly increased on the broad gauge, unless the greater commercial evil were sustained of waiting until full loads were accumulated. For the foregoing reasons, the commissioners decide that the narrow gauge is the most convenient for the merchandise of the country.

3. *On the gauge best adapted for Speed.*—To ascertain this, the time tables of the several companies having fast or express trains were examined, and the returns furnished by those companies of the actual speeds attained by the express trains, during 30 successive days from the 15th June to the 15th July 1845. The commissioners also travelled in the express trains, and noted the speed, mile by mile; the results of which showed that the average speed of the Great Western, both by express and ordinary trains, exceeded the highest speed of similar trains on any of the narrow gauge lines. But some of the latter have trains which exceed the speed of those on the recently constructed lines on the broad gauge; owing to the comparatively unfavourable gradients and curves. These remarks apply to the Bristol and Gloucester, and the Swindon and Gloucester. The inclination and curves on the Great Western between London and Bristol are particularly favourable for high velocities. And it is worthy of remark that in some portions of the narrow gauge lines, where the gradients and curves are very easy, that the speed attained was for a time above that on the Great Western. The difference of effect, according to the nature of the gradients, is shown in a very strong light by a comparison of the time occupied in passing over different portions of the Great Western line. The speed from Paddington to Didcot by the express train is 47¼ miles per hour; from Didcot to Swindon it is 41.1; from Swindon to Gloucester only 31. 7; from Swindon to Bath 48. 2; but returning only 37. 2; from Bristol to Taunton the speed is 46. 3; and from Taunton to Exeter only 39. 2.

It is stated that the locomotive engines on the Great Western line have not been altered from the opening of the railway, (which was designed on the broad gauge in order to obtain higher velocities with equal safety,) while the recently increased speed on the narrow gauge lines has been acquired by the introduction of new engines of greater power; and the commissioners seem to think that they are now as powerful as they can probably be made on the narrow gauge; but that the broad gauge lines have still the means of augmenting the power, and hence the velocity of their engines, within the limits of the stability of roads, to bear such increased weight and motion. Since the introduction of express trains, the accidents arising from running off the line have been more numerous within the last seven months, than within the five preceding

d it is questionable whether this contest for speed ought to be carried reater length.

he opinion of several engineers, that it is the stability of the road, and ower of the engine, that will prescribe the limits of safe speed.

he first introduction of passenger railways, speeds of about 12 miles only were anticipated;" (which is difficult of comprehension, seeing m locomotives on the *common road* went faster,) the rails then employed only 35lbs per yard, and the engines 6 or 7 tons. As soon as the f 20 and 24 miles were attained, they found it expedient to increase to 50lbs per yard, and the engines to 10 and 12 tons. Since that time ts of the rails have been progressively increased from 65 to 85lbs per the ordinary engines on the broad gauge to 22 tons: while those on w are only 2 or 3 tons less, and some few more; one even of 30 tons, heels. This increased weight has been chiefly obtained by lengthen-boiler (augmenting thereby the evaporating surface), and fixing the ylinders on the outside. In such engines as have by this elongation e to overhang the fore and hind axles considerably, the position of de cylinders have had, it is said, a tendency to produce an irregular motion; causing them to be less safe at high velocities. Mr. Stephen-its the existence of this defect in some recent engines, but attributes ely the weight of the piston, which he proposed to counteract by an

mmissioners are, however, of opinion, that this great length of engine ential to the attainment of high velocities on the narrow gauge lines. ed the express trains on four different journeys on the South Western oth directions; that the whole distance was performed very satisfactorily hour and 52 minutes, including the time of stoppages, being at an f 41 miles per hour, on a line which, in one direction, rises for a length than 40 miles on a very prevailing gradient of 1 in 330; and in the s for several miles on a gradient of 1 in 250. On each occasion a of five miles, on a level part of the road, was passed at the rate of 53 hour. The length of the engine boiler was only 8ft. 7 inches, the heels 6 ft. 6 inches in diameter; the leading wheels had both inside de bearings. The diameter of the cylinder in one case was 15 inches, ers 14½ inches, both outside, and attached to the smoke box.

ceeding to compare the locomotive engines, the commissioners remark boilers of the narrow gauge have a smaller power of evaporation than the broad gauge; and that whatever may be the attempts to augment r, it is clear that they may, in this respect, be surpassed on the broad It is, however, a current opinion that the engines on both gauges have ained that speed and power which it would be justifiable to employ, nce to the present strength of the rails and the firmness of the s.

ameter of the driving wheels of the broad gauge engines exceeds that riving wheels of the narrow gauge engines, which circumstance is ably favourable to high speed; because the steam is used to greater , and because the alternating shocks upon the machinery are less rapid. missioners think, however, that at the speed of 40 miles an hour, the between the two engines may be trifling, but that at speeds of 50 or an hour, it may be worthy of notice. It becomes important then to hat may be the greatest desirable speed to be maintained on railways ry purposes. The wishes of the public will be limited only by con-s of economy and safety. The greater the speed the greater will be and it is generally believed that it will be difficult to maintain the xpress speed on the great trunk railways. The chief impediments

he difficulty of entirely protecting the fast trains from interfering with into collision with the slow trains.

he difficulty of seeing signals, especially in foggy weather in time to engine drivers to stop the fast trains.

3 x

4th. *The relative Economy of the different gauges.*—In the first construction of a railway, the narrower the gauge, the smaller will be the cost of the works. This applies to tunnels, bridges, viaducts, embankments, cuttings, sheds, workshops, turntables, transverse sleepers, and ballast, and the purchase of land; but it does not affect the rails, fences, drains, and station-houses. The exact difference, however, must depend in a great degree upon local circumstances.

As to the cost of the maintenance of way, that of the broad gauge must be rather the greater of the two.

The cost of the engines and carrying stock is generally more expensive on the broad than on the narrow gauge. But it is asserted by the advocates of the broad gauge, that as the engines will draw greater loads, the work can be done at a less charge per ton; and that a compensation is thus obtained for the increased outlay. How far this is practically the case is the next subject of inquiry.

The average weight of a passenger train on the Great Western railway (independent of the engine and tender, which weigh 33 tons) appears to be 67 tons; and the average number of passengers per train for the half-year ending the 30th of June, 1845, is only 47.2, whose weight, including their luggage, may be estimated at about 5 tons.

Mr. Gooch, the locomotive superintendent on the Great Western, estimates each carriage and its passengers on the broad gauge to weigh about 9½ tons, and therefore there would be seven carriages to make up the 67 tons above specified. The most commodious carriages on the narrow gauge lines, such as those on the South Western, weigh less than 5 tons; seven such carriages would therefore weigh about 34 tons, and being capable of containing 126 first class passengers, weighing, with their luggage, 12½ tons, the total load would be only 46½ tons. Now we find, that even with a traffic as large as that of the London and Birmingham railway, the average per train would only be 84.9 passengers, weighing about 8 tons; so that, under the supposition of a train of this extent, the load of the seven narrow gauge carriages so occupied would only be 42 tons.

But Mr. Gooch estimates, from his own experiments, the relative powers of traction of the broad gauge engines, and of the narrow gauge engines, of the South Western railway, when working at the same speed, as 2,067 to 1,3[illegible] or as 67 per cent., and the load of the broad gauge in tons, to 45 tons, which would be the corresponding load for the narrow gauge; so that the narrow gauge engine has more power over the 42 tons it would have to draw, than the broad gauge has over its average load of 67 tons, both exclusive of the weight of the engine and tender; the narrow gauge carriages in this supposition being supposed to contain 84.9 passengers, and the broad gauge only 47.2.

It is obvious, from the foregoing statement, that the narrow gauge engine of the class we have been considering, has more power over the seven narrow gauge carriages, and a load of 126 passengers, than the broad gauge engine has over the seven broad gauge carriages, and the load of the same number of passengers; and that, therefore, if the Great Western had been a narrow instead of a broad gauge line, the South Western engines would have had the same command over the existing passenger traffic of the Great Western, as its own engines now have with the present construction of that railway.

The commissioners conclude their investigation of this question, by determining that the work would be performed at about the same expense of locomotive power.

Mr. Gooch has asserted that the Great Western company work their passenger trains at half the expense per ton, at which the London and Birmingham company work their passenger trains. The fact is, however, that Mr. Gooch's calculations refer to the *gross*, and not to the net loads; and therefore, the comparison is not applicable, so far as regards the profits of these companies, and affords no proof of economy in working the passenger traffic on the Great Western system.

In the case of "goods traffic," the circumstances are not the same; railway conveyance for merchandise seems only to be required a few times in [illegible]

day, and the trains are generally large. The "through" waggons have for the most part a full load, and the disproportion between the gross and nett weight is consequently much less than in the passenger trains; still, however, it frequently happens on the London and Birmingham railway, that waggons are forwarded to a considerable distance to "road side stations" containing not more than a ton of goods; which must happen on any long line of railway. The same occurs also in waggons coming in from branches along the trunk line, and in all such cases, the heavy large waggon of the broad gauge must be disadvantageous; but although the evil is not so great with goods waggons of the broad gauge as with their passenger carriages; still the loss by dead weight is greater with these than by the smaller waggons, and we do not perceive any advantage in the broad gauge to counterbalance it; for where speed is not an object, we believe that engines of nearly the same tractive power are to be found on many narrow gauge lines, as those in use on the broad gauge.

Thus far the question has been considered with reference to the railways as they now exist, and composed in a great measure of trunk lines of considerable traffic; but the railways to be made in future will in some degree be branches, or lines, in districts having less traffic than is to be provided for in the existing railways; and hence, if for the greater trunk lines a superiority were due to the broad gauge system, that superiority would be less for lines yet to be constructed, of a smaller amount of traffic; and necessarily, if the preference were given to the narrow gauge for the existing lines, that system would be still more entitled to the preference for the railways of smaller traffic to which we look forward.

Towards the close of this inquiry Mr. Brunel requested, on the part of the broad gauge companies, to institute a set of experiments to test the power of their engines; and Mr. Bidder, on the part of the narrow gauge companies, undertook, in consequence of such application, to make corresponding experiments on the narrow gauge. After sanctioning these trials, and being present at the performance of them, we may observe, without entering into a minute detail of the results, that they proved the broad gauge engines to possess greater capabilities for speed, with equal loads, and generally speaking, of propelling greater loads with equal speed: and moreover that the working of such engines is economical where very high speeds are required; or where the loads to be conveyed are such as to require the full power of the engine. * * *

"After a full consideration of all the circumstances that have come before us, and of the deductions we have made from the evidence, we are led to conclude—

"1st. That as regards the *safety*, accommodation, and convenience of the passengers, *no decided preference is due to either gauge*, but that on the broad gauge the motion is generally more easy at high velocities.

"2d. That in respect of *speed*, we consider *the advantages are with the broad gauge*, but we think the public safety would be endangered in employing the greater capabilities of the broad gauge much beyond their present use, except on roads more consolidated and more substantially and perfectly formed than those of the existing lines.

"3d. That in the commercial case of the *transport of goods, we believe the narrow gauge* to possess the greater convenience, and *to be more suited to the general traffic of the country*

"4th. *That the broad gauge involves the greater outlay*, and that we have not been able to discover either in the maintenance of way, in the cost of locomotive power, or in the other annual expenses, any adequate reduction to compensate for the additional first cost."

The commissioners, esteeming the importance of the highest speed for express trains as being of far less moment than affording increased convenience to the general traffic of the country, consider that the narrow gauge should be preferred for general convenience; and if uniformity should be required they recommend that uniformity to be produced by an alteration of the broad to the narrow gauge; especially as the extent of the former is at present only 274 miles, while that of the latter is 1901 miles; and as the alteration of the former to the latter, even if of equal length, would be the less costly as well as the less difficult operation.

They wish, however, not to be understood to express an opinion that the gauge of 4ft. 8½in. is in all respects the best suited for the general purposes of the country. Some engineers have recommended 5 feet as the best dimension; others have suggested 5ft. 3in., 5ft. 6in., and even 6ft., but none so much as 7 feet, except those who are interested in the broad gauge lines. Again, some eminent engineers contend that a 4ft. 8½ gauge gives ample space for all the railway requirements, and recommend no change to be made in the gauge. The Eastern Counties railway was originally constructed on a gauge of 5 feet, and has since been converted into a gauge of 4ft. 8½in. to avoid a break of gauge; and it has been stated that some lines in Scotland, originally on the gauge of 5ft. 3in. are about to be altered to 4ft. 8½in. for the same reason. * * *

Under the present state of things, we see no sufficient reason to recommend the adoption of any gauge intermediate between the narrow gauge of 4ft. 8½ and the broad gauge of 7 feet; and we are particularly struck by the circumstance, that almost all the continental railways have been formed upon the 4ft. 8½ gauge, the greater number having been undertaken after a long experience of both the broad and the narrow in this country; nor must the fact be lost sight of, that some of these railways have been planned and constructed by English engineers, and amongst that number we find Mr. Brunel, the original projector of the broad gauge. Mr. Brunel was also the engineer of the Merthyr Tydvil and Cardiff line, which is on the 4ft. 8½ gauge; and we think that the motives which led to his adoption of the narrow gauge in that instance would equally apply to many English lines.

We are sensible of the importance, in ordinary circumstances, of leaving commercial enterprise, as well as the genius of scientific men, unfettered. We therefore feel that the restriction of the gauge is a measure that should not be lightly entertained; and we are willing to admit, were it not for the great evil that must inevitably be experienced when lines of unequal gauges come into contact, that varying gradients, curves, and traffic, might justify some difference in the breadth of gauge. This appears to be the view which Mr. Brunel originally took of the subject; for the Great Western proper is a line of unusually good gradients, on which a larger passenger traffic was anticipated, and as it touched but slightly on any mineral district, it embraced all the conveniences and advantages of the broad gauge system, and was comparatively free from the influence of those defects on which we have commented; but such a breadth of gauge, however applicable it may have been considered to a particular district, appears ill suited to the requirements of many of our northern and midland lines.

In reference to the branches already in connexion with the Great Western railway, we may observe, that the greatest average train on the Oxford branch for two weeks in July and October was only 48 tons; on the Cheltenham branch it did not exceed 46; between Bristol and Exeter 53; and between Swindon and Bristol it was under 60 tons. With such a limited traffic the power of the broad gauge engine seems beyond the requirements of those districts.

From an estimate furnished to us, and the general grounds of which we see no reason to dispute, we find that the expense of altering the existing broad gauge to narrow gauge lines, including the alteration or substitution of locomotives, and carrying stock, would not much exceed £1,000,000; yet we neither feel that we can recommend the legislature to sanction such an expense from the public monies, nor do we think that the companies to which the broad gauge railways belong can be called upon to incur such an expense themselves (having made all their works with the authority of Parliament), nor even the more limited expense of laying down intermediate rails for narrow gauge traffic. Still less can we propose, for any advantage that has been suggested, the alteration of the whole of the railways of Great Britain, with their carrying stock and engines, to some intermediate gauge. The outlay in this case would be vastly more considerable than the sum above mentioned; and the cost, inconvenience, and danger to the traveller, and the interruption to the whole traffic of the country for a considerable period, and almost at one and the same time, would be such, that this change cannot be seriously entertained. Guid

By the foregoing considerations, the commissioners submit the following recommendations to the legislature:—

1st. *That the gauge of 4ft. 8½in. be declared by the Legislature to be the gauge to be used in all public railways now under construction, or hereafter to be constructed, in Great Britain.*

2d. *That unless by the consent of the Legislature, it should not be permitted to the directors of any railway company to alter the gauge of such railway.*

3d. *That in order to complete the general chain of narrow gauge communication from the north of England to the southern coast, any suitable measure should be promoted to form a narrow gauge link from Oxford to Reading and thence to Basingstoke, or by any shorter route connecting the proposed Rugby and Oxford line with the South Western railway.*

4th. *That as any junction to be formed with a broad gauge line would involve a break of gauge, provided our first recommendation be adopted, great commercial convenience would be obtained by reducing the gauge of the present broad gauge lines, to the narrow gauge of 4ft. 8½in. and we therefore think it desirable that some equitable means should be found of producing such entire uniformity of gauge, or of adopting such other course as would admit of the narrow gauge carriages passing, without interruption or danger, along the broad gauge lines.*

Cleansing Rails.—To avoid the impediment that is likely to occur occasionally from snow or ice upon railways, Mr. Grime, of Bury, has proposed, under a patent right, dated the 21st February, 1831, to dissolve the same by making the rails hollow, and causing hot water, steam, or hot air, to pass through them, so as to keep them at a temperature above the freezing point. For this purpose boilers are to be erected by the side of the railroad, at distances of two or three miles from each other. One of these boilers being supplied with water, and heat applied, the water is forced, by the pressure of steam on its surface, through a pipe communicating with the hollow rail, and reaching nearly to the bottom of the boiler, and along the railway, till it ceases to give out a sufficient quantity of heat to melt the snow or ice which may lodge on the rails, when the water is received into another boiler by means of a feeding vessel placed over it. This feeding vessel is connected with the boiler by two pipes,—the one descending from its bottom to very nearly the bottom of the boiler, to form a water communication, and the other from its top to the top of the boiler, to form a steam communication. Each of these communications is provided with a stop-cock and levers, both of which, as well as one from a cock on the pipe which supplies the feeding vessel, are connected with a float in the boiler, by means of a wire passing through a stuffing-box, in a manner similar to that in Eng. Ency. Vol. I. p. 216, where the float descends by the escape of water through the exit pipe into the rails: the steam and water communication from the feeding vessel to the boiler are thereby opened, while the supply pipe to the feeding vessel is closed, when the water contained therein is forced, by the pressure of steam on its surface, into the boiler, till the float is elevated so as to close the communication between the feeding vessel and the boiler, and to open that between it and the hollow rails, for the admission of a fresh supply of cooled water.

It is stated in the specification, that instead of the hollow rails, hot water pipes may be laid along the line of road, in contact with rails of the usual construction. The lengths of hollow rail are connected together by pieces of copper pipes fitting accurately into the ends of the pieces of hollow rails, which they unite, leaving a space between them sufficient to allow of their expansion by the increased temperature.

For the purpose of cleansing the rails from snow, grease, or sand, while the engine is travelling thereon, Mr. Melling applies small jet pipes, which hang immediately over the centre of each rail, and through these pipes, by means of a swivel cock, connected with the boiler, either steam, or hot water and steam, may be at any time blown, so as to make the rails perfectly clear and dry, which (in snowy or frosty weather, or at the station ends of the rails, where they are always greasy) will be found to prevent the slipping effect of the wheels;

especially when used in combination with the patentee's improved coupling, described at page 452.

Water Crane.—The mechanism for supplying the tenders of lo engines with water, necessarily differs according to its situation, the p the source whence the water is derived, and other circumstances; arrangement usually consists of a cistern elevated about 10 or 12 feet railway, from which the water flows into what is termed a water crane, or neck of which turns on a pivot, and permits the water to be discharged by the opening of a valve or cock, into the reservoir of th In the following cut, *Fig.* 1, is given an elevation of a water crane, wi proved valve applied thereto by Mr. Underhay, and for which he has a patent. The external form of this portion of the water crane is sh but in order that it may be better explained and understood we hav this new "Cam-valve cock" (as the inventor terms it) in section, on scale by *Fig.* 2. At *a* is the valve-box; *b* the inlet pipe; *c* the out

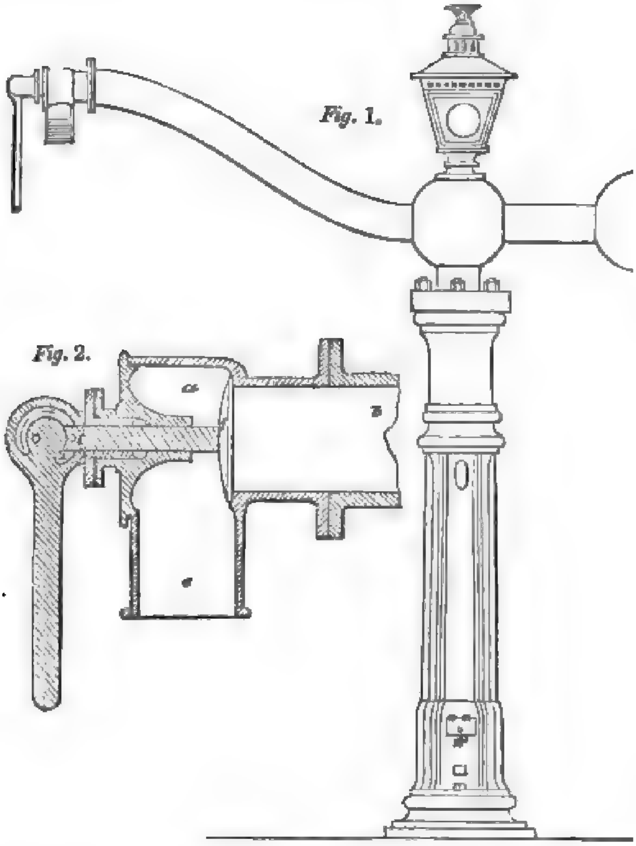


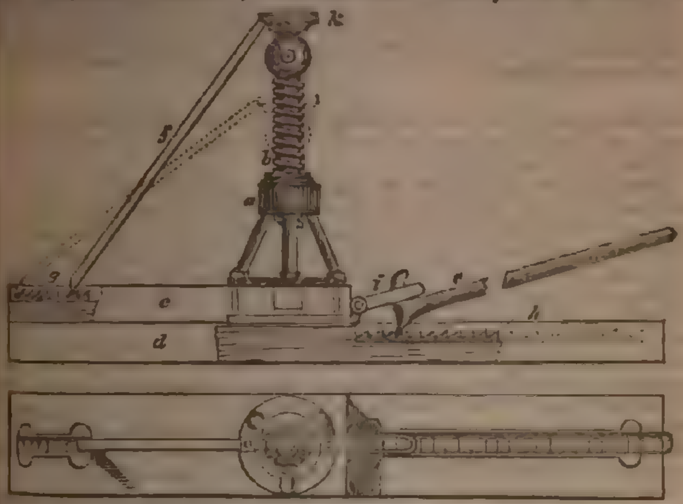
Fig. 1.

Fig. 2.

f the valve, *g* the spindle which works through the stuffing box shown handle to the cam, which is cut away on both sides and through to t shown, and an arched piece *s* is left standing out from the centre (wh endwise), with an open space between it and the body of the cam. T spindle has a cleft made in the upper end of it, the two cheeks of wh

cross pin *t*. The arched piece *s* of the cam is inserted in this cleft behind the cross pin *t*, so that when the cam handle is brought down into the position shown, the cam acts upon the spindle and closes the valve with an intensity of force, insuring the contact of the opposite surfaces by merely the weight of the lever handle. To open the valve, it is of course only requisite to lift the handle. The simplicity of construction of this valve apparatus, and the ease and certainty of its operation, render it a very desirable appendage to railway water cranes.

Curtis's Traversing Jack.—The accompanying figures represent Curtis's "Traversing screw jack" for replacing an engine or carriages upon the rail. The screw jack *a* is bolted to the plank *c*; at the other end of the plank is fixed the rack *g*, in which the toe of the strut advances as the screw *b* is elevated; the strut works in a joint in the follower *k*; the position of the strut when the screw is depressed is shown by the dotted lines. The object of this strut is to



relieve the screw of the violent cross strain, to which the apparatus is subject when the engine or carriage is pulled over by the lever, which strain is entirely transferred to the strut, and the screw has merely to carry the load.

The operation of traversing the jack is as follows:—by hooking the link *i* upon the hook of the lever *e*, the toe of the lever being inserted into a notch of the rack *n* of the lower plank, a man, bearing down the end of the lever, drags the apparatus and engine or carriage towards him with great facility: the same lever is used to turn the screw and to produce the traverse motion. By this apparatus an engine of 16 tons weight has been replaced upon the rails in five minutes by the engineer and stoker alone; thus those delays which are the subject of so much annoyance and loss to railway proprietors and the public need not happen in future. The apparatus is exceedingly portable and cheap, and no train ought to be allowed to go out without its being sent along with it: it may be carried either upon the tender, or upon some other place which may be selected for it.

COST OF RAILWAYS PER MILE.

The London & Blackwall	£2[illegible]7,[illegible]93	The Midland Counties	35,402
London & Greenwich	267,270	Edinburgh & Glasgow	35,[illegible]24
London & Croydon	[illegible]100	Birmingham & Gloucester	[illegible],000
London & Kingston	59,122	London & South Western	28,[illegible]
London & Brighton	60,[illegible]	North Union & Bolton & Preston	27,799
Great Western	56,372	Grand Junction	22,293
London & Birmingham	52,882	York & North Midland	23,666
Liverpool & Manchester	50,[illegible]23	Glasgow, Kilmarnock & Ayr	20,607
Manchester & Leeds	47,[illegible]24	Dublin & Drogheda	15,652
Glasgow & Greenock	35,451	Dundee & Arbroath	8,570

SECTION III.

LOCOMOTIVE ENGINES AND CARRIAGES.

Increased efficiency of modern Locomotives.—Similarity in the general features of construction.—Stephenson's Patent Engines.—Melling's Patent Engines with new Couplings, and Breaks, and Slidevalves.—Tayleure and Co.'s six wheeled Engines.—On the comparative advantages of four and six wheeled Engines.—Bury and Co's defence of four wheeled Engines, with a "Practical Engineer's" reply thereto.—Remarks thereon.—Experiments on the Grand Junction, and London and Birmingham lines.—Wyndes and Ericsson's improvement for ascending Inclined Planes.—Kollman's Locomotive Guides.—Prosser's Guide Wheels.—Stephenson's compound Axles.—Ledi Patent Wheels.—Lipscomb's Patent Wheels for preventing Vibration and Noise.—Dunk's Welded Felled Wheels.—Mode of fixing Tubes in Boilers.—Water Gauge.—Water Ash box.—Bened Buffers.—Mallett's Buffers.—Terminus Buffer.—Curtis's safety Passenger Carriage.—Curtis's improved Truck for the conveyance of Carriages.—Booth's Railway Connecters, and mode of chocking Speed.—Hick's Locomotive Engine.—Booth's Patent Axle Grease.

Having explained the various arrangements of the railway and its accessories, we now proceed to describe the construction of the several kinds of vehicles which run thereon.

Since the first introduction of railways for passenger traffic by locomotive engines, that is to say, since the opening of the Liverpool and Manchester line, the efficiency of the engines has been greatly augmented; those of the present day transporting much heavier loads at a greater speed, and at a less cost, than the engines of 15 years back. This is owing partly to increased dimensions of the boilers, and the steam cylinders, and somewhat to the splendid accuracy of workmanship and solidity of construction which the keen rivalry of the manufacturing engineers has induced them to put forth: to which may be added many improvements in the details of the machinery; some tending to simplify and reduce friction, others to create new effects and to increase efficiency. Nevertheless, in the principal combinations, and the general features of the whole structure, there is a certain similarity, which while it attests their relationship, distinctly shows the intellectual training to which they have been submitted by the mechanists of the present day.

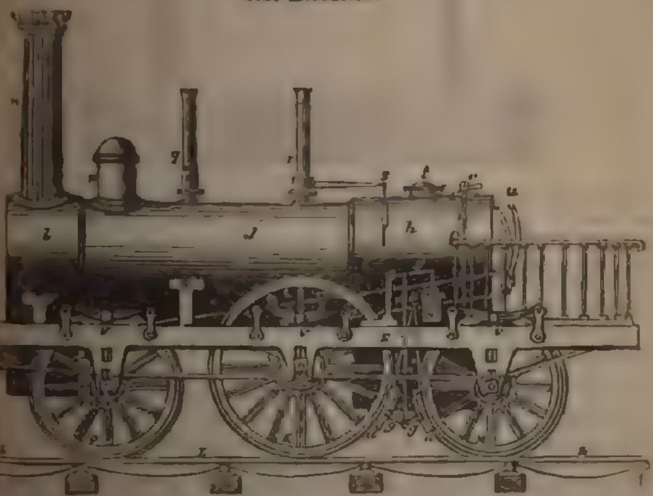
The boiler is almost universally composed of a vertical compartment (square or cylindrical in its horizontal section), containing within it the furnace, (now designated the "fire-box,") surrounded by water; this vertical compartment opens into a horizontal cylindrical chamber, containing the greater portion of the water, which is heated by the gases and flames proceeding from the fire through an extensive series of small tubes of thin metal, lying horizontally in parallel straight lines throughout; one end of every tube being open to the fire, to receive the heated current, and the other end opening into a vertical "smoke box," at the other extremity of the horizontal cylindrical chamber. Into this smoke box is discharged all the smoke and gaseous products of the combustion, which escape in a rapid current, excited by a blast produced by the escape of the eduction steam into a small chimney, erected immediately over it. The requisite supply of fuel for the journey, and of water for evaporation is carried by a judiciously contrived machine called a tender, which is linked close to the engine.

The principal diversities in the construction are to be found in the number and position of the wheels; in the description of the framing, which sometimes extends outside the wheels, and sometimes lies within them; and in the position of the steam cylinders, and the mode of connecting them with the shaft of the driving wheels. In some engines the steam cylinders are placed in the smoke box, and the connecting rods transmit the force to two cranks, forged at right angles to each other, near the middle of the axle of the driving wheel; whilst in other engines the steam cylinders are placed outside the frame, the driving shafts are straight, and the connecting rods are attached to cranks fixed

each end of the shaft, or to pins in the bosses of the wheels. In the early part of the working of the Manchester and Liverpool railway, the locomotive engines were generally constructed with a double cranked axis upon the two main wheels of the carriage; which wheels were provided with flanges on their peripheries to keep the engines on the rails. But this mode of construction was considered by Mr. Stephenson to be defective, owing to the liability of the crank axis becoming strained or broken by the excessive friction of the flanges against the rails, especially in making deviations from the straight course. Any lateral bending of the cranked axle, although short of a fracture, will, it is evident, by putting the wheels out of square, produce a violent surging motion of the engine, and render a fracture of the axle, or the running of the engine off the rails, extremely probable. To provide a remedy for such serious liabilities, Mr. R. Stephenson, under his patent of 1833, divested the tires of the main impelled wheels of their flanges, and in lieu thereof, employed two small additional wheels with flanges behind the former. These additional wheels are applied beneath the fire-place end of the boiler, for keeping the engine straight on the rails in its progress forward; and the axles of these wheels being straight, and consequently stronger than the cranked, are not liable to be broken or bent, as experience has proved with respect to the axes of the fore wheels, which remained unaltered.

The engines made by Mr. Stephenson to carry out these improvements we shall now proceed to describe with reference to the annexed cuts, designed to illustrate the same. At K K are main impelled wheels on the cranked axles, without any projecting flanges on the tires, which run on the edge rails L. M are the additional small wheels with flanges, applied beneath the furnace end of the boiler; and O are the ordinary small wheels with flanges beneath the chimney end of the boiler, where the working steam cylinders are situated. The small wheels O and M with flanges, keep the engine straight upon the rails, and the large impelled wheels K have only to advance the engine, and to bear a due proportion of the weight. By this arrangement, therefore, the

Side Elevation.

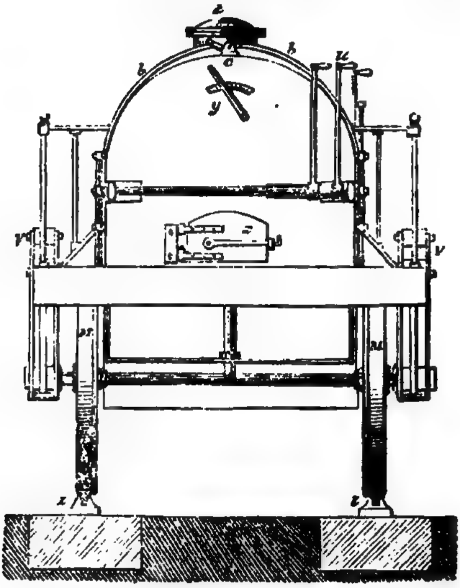


cranked axle is liberated from all lateral strain, which is wholly transferred to the small wheels with flanges, which, having straight axles, are capable of sustaining it.

It is often of essential importance to be able to arrest the progress of a carriage on a railway with great promptitude; and the breaks in ordinary use

for this purpose have not always been found sufficiently potent. As a remedy for this inconvenience, Mr. Robert Stephenson, under the same patent, proposes to employ the force of steam acting upon pistons or plungers in small cylinders; so that when it is required to stop the train it is only necessary to turn a small cock, which allows the steam to flow instantaneously through a pipe into the cylinder, and by its pressure on the piston give motion to a system of levers, which cause two breaks or clogs to be forced against the peripheries with great energy, and to arrest the motion of the vehicles very quickly. These clogs or breaks, and their mode of action, are shown in the side elevation on the preceding page. *a* is the hollow cylinder into which a plunger is fitted, to act by a lever *y*, and an upright rod *f*, upon the two brakes *d d*, which are suspended

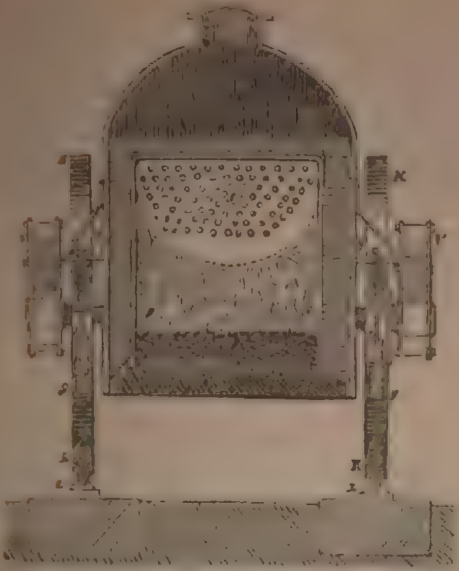
End Elevation.



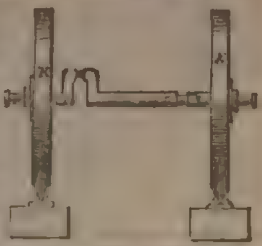
by pendulous links *x* from a centre pin or bolt *e*, fixed to the frame. The breaks are caused to apply to the circumference of the tires of the wheels K and M, by means of links, which are interposed between the two breaks, and which links, when put down into an angle, as shown in the figure, leave the breaks free of the wheels K and M; but when, by opening the cock *c*, the steam from the boiler is admitted through the pipe *b b*, into the hollow cylinder *a*, it raises up the plunger therein; and the latter, by its lever *y*, and rod *f*, draws up the links towards a straight line, and then they force the two breaks apart from each other, against the wheels K and M, with an increased force beyond that which the plunger exerts; that increase of force being in consequence of the leverage at *y*, and the oblique direction of the links. When the handle of the cock *c* is turned the other way, it allows the steam to issue through an upright spout, and escape from the cylinders into the open air.

The following letters have reference to the other parts of the engine. At *h* is the fire-box; *i* the ash-grate; *j* is the boiler, cylindrical in shape through the lower part of the transverse sectional area of which are passed longitudinally a great number of small brass tubes, proceeding from the furnace chamber, which serve as the hot-air flues, and conduct the same into the smoke-box *l*, at the other end, whence the gases resulting from the combustion of the fuel ascend the chimney *n*; *p* is the steam-head; *q* a safety-valve;

Transverse Section.



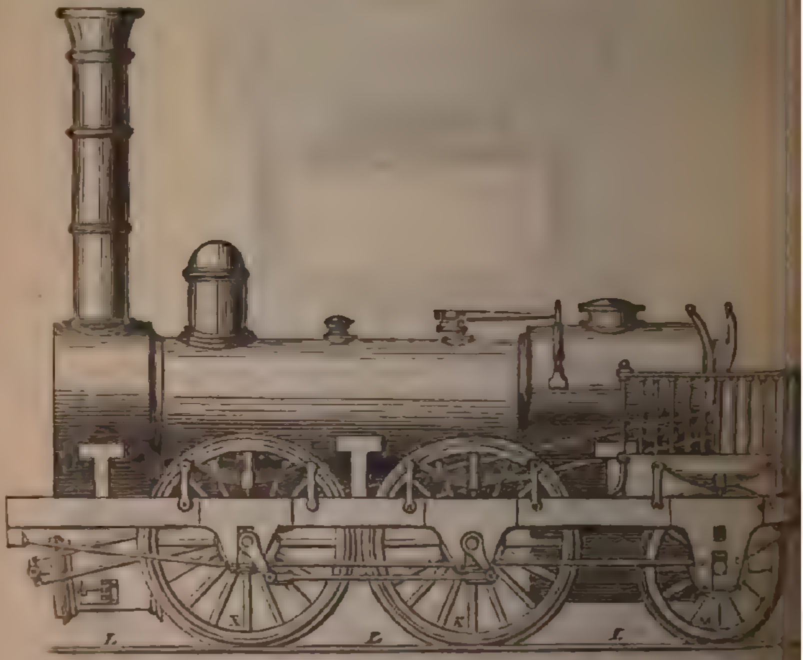
r another valve, the extremity of the lever of which is held down by the elastic force of a spring steel-yard at *s*; *t* is a man hole; *u* the working geer; *v v v* the springs; *w w* the iron brackets that connect the machinery to the wooden frame; *x* the fire-door; *y* the throttle-cock, provided with a lever and graduated scale. In the end elevation it will be observed that the axes of the running wheels M, like those at O, are straight; the form of the axles to the wheels K, is represented in the annexed cut, and they are forged with great care from the toughest quality of iron, and are turned and centred, as well as the running wheels, in the lathe.



Locomotive engines, constructed according to the description of the foregoing Mr. Stephenson says, have the effect of preventing the boilers being burnt out so soon as usual, by allowing them to be made of greater magnitude and strength; the additional wheels supporting the extra weight. The bearing springs are used for the extra small wheels, the same as is now done for other wheels in ordinary engines; the six springs used causing all the six wheels to apply and bear fairly on the rails, and ease all jolts and concussions; the relative weights, or portions of the whole weight of the engine, which is to be borne by each of the six wheels, being regulated by the strength and setting of their respective bearing springs. The main wheels, which are impelled by the power of the engine, are, in all cases, left loaded with as much of the weight of the engine as will cause sufficient adhesion of those wheels to the rails, to avoid slipping thereon. The larger the entire capacity of a boiler is, the more extensive heating surface it will contain; and, consequently, render unnecessary that intensity of heat which is so prejudicial to the metal. And the jet of eduction steam which is thrown into the chimney to produce a rapid draught therein, may be greatly diminished in its velocity, which will permit the eduction steam

to escape from the working cylinders with greater freedom than could be permitted with smaller boilers, wherein a greater heat and a more rapid generation of steam are indispensable to furnish the requisite power.

The annexed cut exhibits another form of Mr. Stephenson's locomotive engine, but with the foregoing improvement added thereto. The foremost wheels, at the chimney end of the boiler, are, in this, however, impelled by means of outside cranks and connecting rods, as well as the two middle wheels K, which are on the cranked axle; in other respects, the improvement is the same as in the other engine. The breaks, or clogs, are, of course, applicable to this or any other engine, but they are left out in this instance, as being unnecessary to our illustration.



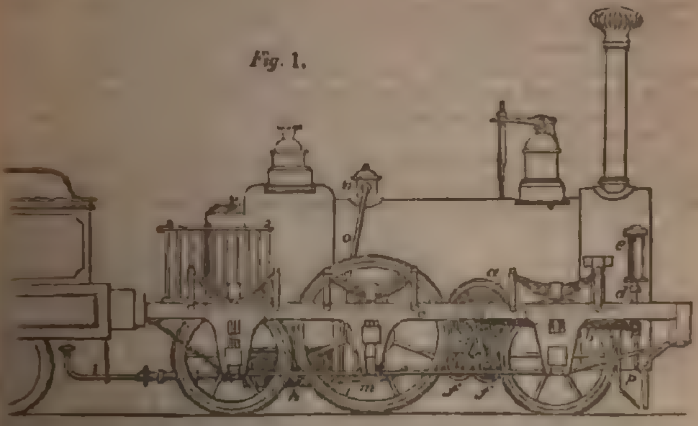
Melling's Patent Couplings and Breaks.—To obviate the inconvenience and waste of power by the slipping of the wheels of locomotives on railways when they are in a wet or greasy state, Mr. John Melling, of Liverpool (the manager of the locomotive department of the Manchester and Liverpool railway,) has devoted much of his attention. In the specification of his patent granted in July, 1837, and reported in Newton's Journal for January, 1841, (whence we derive the following account,) he observes:—

"My improved method of coupling the engine wheels is effected by the application of a pair of friction wheels or rollers, of any suitable diameter, placed between the peripheries of the driving wheels, and the running wheels of the locomotive carriage. This assistance is, however, only required in those instances where the weight upon all the wheels is not uniform, or sufficient to prevent some of them slipping upon the rails; the quantity or degree of friction being readily accommodated to circumstances, and the connexion or coupling between any two wheels, whatever their respective diameters may be, produced or removed at pleasure. This contrivance is very advantageous in comparison with the ordinary previous mode of coupling, because, if the rails be dry or

the adhesion be sufficient, the anti-friction wheel couplings may be lifted off and remain unused, while the ordinary system of outside cranks and connecting rods must always continue working, and thus, at certain times, only act as an incumbrance. Another important feature in this improved mode of coupling the wheels, is the smoothness with which the engine works when the cranks are passing their centres, instead of being subjected to the sudden blows and jerks which occur to engines coupled in the ordinary manner. This improvement is effected by transmitting a considerable portion of the weight from the cranked or driving axle to the straight or independent axle, which entirely prevents the tremulous lateral motion of ordinary locomotive engines; passing over inequalities in the surface of the road; and tending greatly to prevent the destruction of the engine springs, and the beating of the rails, usually attendant upon such occurrences.

In the subjoined engravings *Fig.* 1 represents a side elevation of a locomotive engine, in which the before-mentioned improvements are introduced, and some others which we shall describe afterwards. To avoid confusion, many of the ordinary details of a locomotive engine are left out as unnecessary to our present object.

Fig. 1.



At *a* is the improved coupling wheel, in its proper position for connecting the driving wheels upon the crank shaft, with the running wheels upon the fore axle of the engine. One of these coupling wheels or rollers is placed on each side of the engine, and bearing upon the periphery of the driving and running wheels; they are suspended in wrought iron levers *b*, the fulcra of which are at the end *c*, and the other ends of these levers are attached to piston rods *d*, which work in small steam cylinders *e e*, which have a steam cock in common, to admit the steam from the boiler. Now it will be seen that when it is necessary to couple the engine wheels, in order to obtain more adhesion upon the rails and prevent the slipping of the engine, the cock is to be opened, which by letting steam into the tops of the cylinders causes their pistons to descend and depress the levers, which forces the coupling wheel *a* into contact with the peripheries of the driving and running wheels of the engine, as long as the steam is allowed to remain in the cylinder. When the coupling wheel is no longer required to act upon the engine carriage wheels, it may be dispensed with, by turning the steam in at the bottom of the small cylinders, which raises the pistons and levers, and consequently lifts the coupling rollers from off the peripheries of the driving and running wheels. These coupling wheels are formed with a groove in their peripheries, wherein the flanges upon the tire of the carriage wheels run, and serves to keep them effectually in gear, and at the same time prevent the distance between the wheels ever becoming too narrow

for the width of the rails, in the event of the wheels loosening upon their axles, which occurrence has frequently thrown the engine off the line of railway. Thus it will be seen, that the wheels of the engine may be coupled and uncoupled at any rate of speed they may be running, and without difficulty or interruption, without any restriction as to dimensions in the driving, running, or coupling wheels. (It is also deserving of remark that this coupling wheel is not confined in its application to locomotive engines, but may be applied as a medium for driving all kinds of machinery, in order to dispense with any jerking or unevenness of motion occasioned by toothed gearing, or in order to obviate the difficulty frequently arising from the teeth of wheels breaking).

In connexion with the before-mentioned apparatus and illustrated by the same figure is an improved drag or break. At *f f* are two small anti-friction rollers, suspended from the levers *b*, their own peripheries being in contact, but hanging in guides *h h*, entirely free from the peripheries of the engine carriage wheels; and when it is necessary to stop the engine, it may be done with great rapidity and ease by letting the steam into the bottom of the cylinder *e*, thus raising the lever *b* (at the same time releasing the coupling wheel *a*), and bringing the peripheries of the two rollers *f f* into close contact with the tires of the engine carriage wheels, and thus effectually to lock them or impede their progress, by immediately reversing the direction of the revolution.

The same system of apparatus is applied to the tender, but with a different mode of putting the same into operation, as the rollers are there drawn into contact by a vertical screwed rod and suspended links; which construction will be found most suitable for tenders and carriages used for the transit of passengers and merchandize.

The annexed diagram is explanatory of another modification of Mr. Melling's friction couplings, which he considers to be also an improved arrangement for such engines as are employed to convey heavy trains and merchandize.

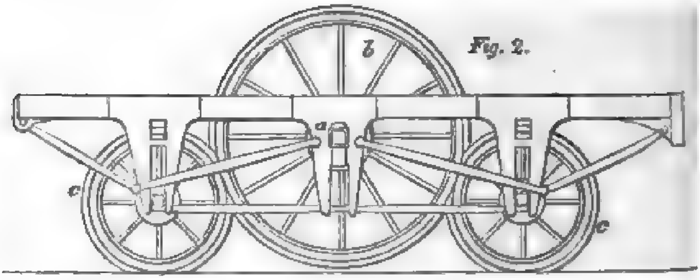


Fig. 2.

At *a* is the main cranked or driving axle, in the centre of the engine; upon the ends of this axis, two large driving wheels *b* are fixed, so as to run just clear of the rails; but so as to bear forcibly upon the fore and hind wheels *c c*, and thus transmit the power of the engine through them, and obtain a perfect adhesion upon the rails at all points.

With a view of showing in a strong light the great practical advantages

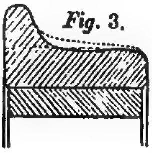


Fig. 3.

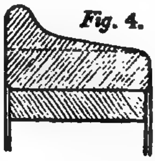


Fig. 4.

attending the patent coupling wheels, Mr. Melling exhibits two diagrams in his specification representing the wear upon the tire of a wheel by the use of his coupling, and without it, which we shall herewith add.

. 3 represents the amount of wear upon the true cone of the tire of wheels gines that have run without being coupled, and therefore entirely the effect pping against the rails. *Fig.* 4 shows a wheel which has performed the number of journeys as the other, but which has been coupled according to atentee's method. In the latter, owing to the entire prevention of slipping, is no perceptible wear.

nother improvement effected by Mr. Melling, and described in the London nal for January 1841, consists in a combination of apparatus for working lide-valves of locomotive steam engines, which he states "entirely nses with the imperfect mode of working them by excentrics," as hitherto sed. The great reduction of friction effected by it is equivalent to a sponding increase of power. "A farther improvement, arising from this of working the slide-valves, is, that they are driven from the ordinary con- g rod instead of being worked by excentrics mounted on the crank shaft, as fore; in which case, if by any accident the crank shaft happened to have be- bent or broken, it could not effect the opening and closing of the side valves.

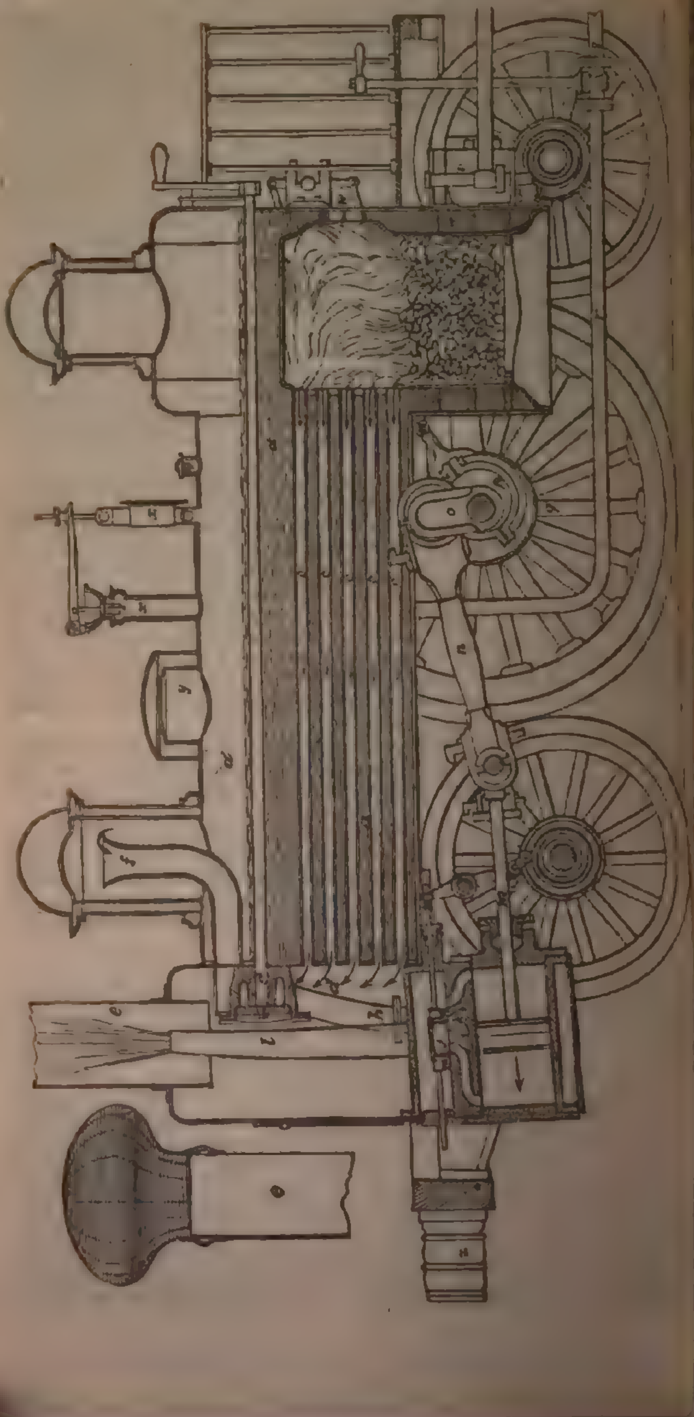
ving now given several external views of the more modern form of six- led locomotive engines, and their principal accessories, we shall proceed ibit the *internal* construction of the parts, by an enlarged section of an e constructed by Messrs. Tayleure and Company, and shown on the follow- ge.

a a is the boiler, consisting of a horizontal cylindrical chamber connected ertical chamber, containing within it the fire box *b*, which is surrounded ter. *c c c* are a series of horizontal tubes of small diameter, serving as flues h which the heat is imparted to the horizontal portion of the boiler, and g into the smoke box *d*, which is surmounted by the funnel or chimney *e*, as broken off for want of space. At *f* is a bell-mouthed pipe (rising hin a dome to prevent the water passing over with the steam), which com- cates with the throttle valve *g*, whence the steam is conducted by branch *h* to the two cylinders *i*. At *j* is the slide valve, *k* the eduction aperture unicating with the blast pipe *l*; *m* is the piston rod, *n* the connecting rod, of the driving cranks formed upon the axle, *p* one of the excentrics govern the motion of the slide-valves.

q is one of the driving wheels, *r* the feed pipe, the supply of water being ated by the cock *s* through the medium of the key *t*; *v* is the connecting *w* the hand or starting gear, *x x* the steel-yard safety valve, *y* the man hole, the buffer.

may be observed that the boiler is encased with wood to prevent the loss of from radiation; and for the same purpose the steam chests, or domes and holes, are provided with a thin metallic casing (generally of brass) leaving a w space of air between them. The top of the chimney is covered by a of coarse wire-work to prevent the escape of red-hot cinders, for the want ch precaution many accidents have occurred.

ur-wheeled and six-wheeled Railway Locomotive Engines.—A difference nion has of late years existed amongst Railway engineers as to the rela- erits of four and six-wheeled engines. Amongst the advocates of each are men of talent and experience; and amongst the locomotives made h plan there are many of a highly efficient character; and all seem constructed with so much solid beauty of workmanship, as to render very imposing examples of mechanical skill. The frabrication of these ed machines can only be conducted with due economy in large works, the self-acting machinery is elaborate, powerful, and of the highest . Hence the manufacture of railway locomotive engines is confined to ratively few establishments, amongst whom there is a rivalry for pro- the best engines. And when any accident occurs to an engine, it is too attributed by a rival to a defect in its construction, which may not have uted to it in the slightest degree. To arrive at a correct knowledge of mparative economy and mechanical advantages between the engines of



rival companies, any ordinary inquirer would meet with insuperable difficulties; because, the advocates and parties he must consult on either side are generally interested in the result. The only means of attaining *certain* information, would be by the appointment of a parliamentary commission of able and independent men, similar to that which recently so admirably investigated, and decided the question of the rival gauges; which commission would have the power of calling for *all* the evidence that could be obtained, and of proving experimentally the facts elicited. If we are to believe the statements of the rival parties who have figured in this paper controversy, it is not merely a question of science, or of public convenience that has to be determined, but one wherein life is placed in serious jeopardy; one party going so far as to charge the other with the sacrifice of "*more than a hundred lives*," by persisting in their supposed erroneous system of construction!

The chief manufacturers as well as champions of the four-wheeled locomotive engine, are Messrs. Bury, Curtis, and Kennedy, of the Clarence Foundry, Liverpool, who make them for the London and Birmingham railway, where they have been continually and exclusively used, we believe ever since its first opening. "To show the process of reasoning by which, aided by experience and the closest observation, they have arrived at the conclusion of preferring the four-wheeled to the six-wheeled engines," they sent forth a Circular in vindication, accompanied with engravings of the "Albert." To this measure they were induced, they state, because "there have not been wanting those whose anxiety to feed the public prejudice, and to profit by the effect of it, has led them to allege many things against four-wheeled engines, which are both untenable in principle, and untrue in fact," and because "in all the discussions which have taken place on the subject, none, or scarcely any stress, has been laid on that which is substantially the main feature of the whole case; namely, the different effects of inside and outside bearings." This Circular has been answered in the pages of the Mechanics' Magazine by a rival party, under the anonymous signature of "A Practical Engineer," who, we are assured by the Editor of that excellent Periodical, is a gentleman of as high authority on railway matters, as Messrs. Bury, Curtis, and Kennedy.

We shall now proceed to give the Circular of Messrs. Bury & Co., and place in juxta-position the answer to it by a "Practical Engineer," to save needless repetition and space, and for the convenience of our readers.

To render the arguments of Messrs. Bury, Curtis, and Kennedy in favour of their four-wheeled locomotives more readily intelligible, we shall first lay before the reader the drawings and description of the "Albert" four-wheeled locomotive, combining their recent improvements.

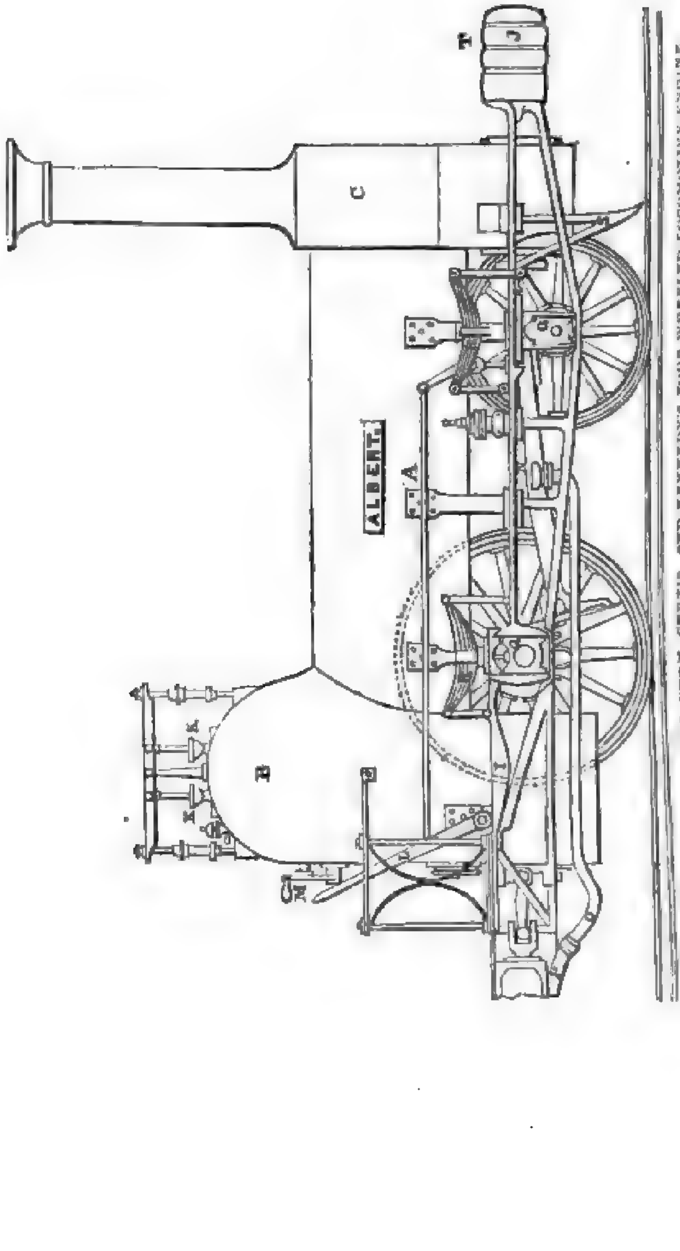
Messrs. Bury, Curtis, and Kennedy's Circular.

1. The Manchester and Liverpool railway was the first that ventured upon the use of steam locomotive power, for the conveyance of passengers at a rapid rate, and the first engine made for that great and spirited undertaking, in 1828, had six wheels. This engine, however, failed to give satisfaction, and a premium of £500 was, in the same year, offered by the Directors for the best engine. After many trials the premium was awarded to a four-wheeled engine.

On the foregoing paragraph 1, the "Practical Engineer" states, that the engine supposed to be alluded to (The Twin Sisters) was not accepted by the Company, "because it would not generate steam enough for the speed required, and *not* because it had six wheels, or *outside* framing, as the framing was not of that kind."

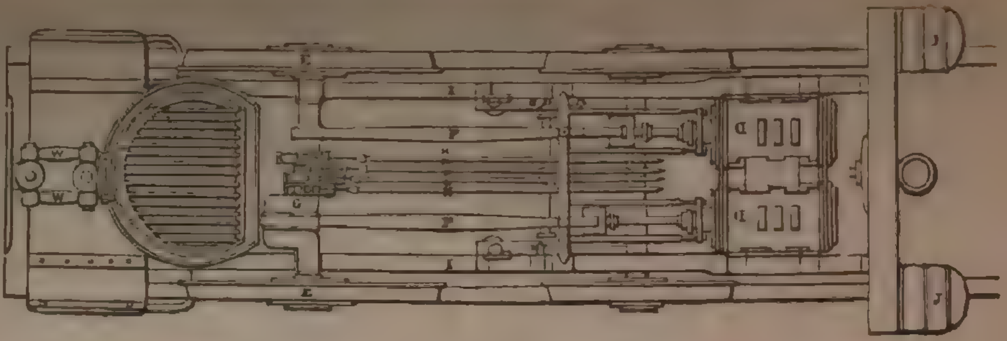
2. The four-wheeled engines of that day had all of them outside frames, and were used on the Liverpool and Manchester railroad for four or five years, without other objections than the loss from the breakage of axles, arising from the defective plan of the frame, viz., in its being placed outside the wheels.

In reply to paragraph 2, the "Practical Engineer" says, "The following engines were the first employed on the Liverpool and Manchester railway after its opening, and all of them had *inside* framings, crank pins in the leading wheels, with four wheels each; namely, the Rocket, Meteor, Arrow, Comet, Dart, North Star, Northumbrian, and Majestic."



SIDE ELEVATION OF MESSRS. BURY, CURTIS AND KENNEDY'S FOUR-WHEELED LOCOMOTIVE ENGINE.

PLAN OF MESSRS. BURY, CURTIS, AND KENNEDY'S FOUR-WHEELED LOCOMOTIVE ENGINE.



A, is the boiler; B, fire-box; C, smoke-box, in which are placed the cylinders; D D, the cylinders (valve-box, and valves removed); E E, driving wheels; F F, connecting rods; G, crank axles; H H H H, excentrics for working valves; I I, framing of Engine; J, buffers; K K, safety valves; L, starting and reversing handle; M, steam cock for regulating speed; N N, brass pumps for supplying boiler with water; O O, pipes for conducting water from tender to pump; P P, leather hose between engine and tender; Q Q, bushes for axles; R R, springs; S S, guards for clearing rails; W W, links connecting the engine to tender.

3. Experiments were subsequently made, intended to show that economy of fuel resulted from the use of a large fire-box; but the consequence was, that this part of the engine became so heavy as to require support behind it, and hence arose the re-introduction of a third pair of wheels, which had been previously abandoned as highly objectionable.

> "Owing to the frequent occurrence of accidents with, and the pitching and sinuous motion of the four-wheeled engines, it was resolved to try the effect of six wheels, by putting an additional pair under two of the Company's old engines, namely, the Atlas, and the Man." "The result of the experiment gave so much satisfaction, that I believe all the Company's engines which were thought to be worth the expense, were made into six wheelers; and the engines which are now (1843) making for that line, are six wheelers. It is altogether erroneous, therefore, to say that the third pair of wheels was introduced on account of the use of large fire boxes."

4. The engine makers, generally, of the country had no choice of the form of engine, but had to conform to the plans of the directors or engineer of the Company, and did not examine minutely the merits of the new plan of construction, and engines continued, for some years, to be made ordinarily with outside frame, large fire-box, and six wheels.

5. It was the good fortune of the conductors of this foundry to originate the construction of four-wheeled engines, with inside framing, crank axles, and cylinders, placed in the smoke-box, all the practical and mechanical objections to the six-wheeled engines, and particularly with outside framing, having been foreseen at the earliest period. The first engine made upon this principle was manufactured in this foundry, in 1829, prior to the opening of the Liverpool and Manchester railway. As the principle of the four-wheeled engine thus made gained publicity, great alterations have been introduced, from time to time, in ordinary six-wheeled engines, and at last we find, which we may be pardoned for adverting to with some satisfaction, that in the latest invention of an eminent engineer, the outside framing is now being abandoned, or at least, that the inside framing has been adopted in that instance, and the large fire-box dispensed with.

> In reply to paragraph 5, the "Practical Engineer" says, "I am not prepared to say that Messrs. Bury and Co. were not the first who constructed engines of 'four wheels, with inside framing, crank axle, and cylinders placed in the smoke-box,' considered as a combination of parts; but taking this statement in connexion with other parts of the circular, it is calculated to produce a very false impression, and I have met with several persons who have been misled by it." "Every person at all acquainted with railways, must know that outside framing is of comparatively recent date, long subsequent to Messrs. Bury and Co. becoming engine makers. The reference made in the latter part of this paragraph to the use of inside framing, by an 'eminent engineer,' is one of the boldest things I ever saw. It can hardly be possible that persons engaged in the construction of locomotive engines so long and so extensively as Messrs. Bury and Co. have, can be ignorant of the fact, that Mr. G. Stevenson made engines with inside framing more than 30 years ago. Even if they did not know that fact, can any body conceive it possible that they should so soon forget that the Rocket, and many other engines subsequently made by Mr. R. Stephenson for the Liverpool and Manchester Railway Company, had inside, and not outside framing? You will observe that it is not stated that that 'eminent engineer' is *now* adopting the inside framing for the first time, but that the outside framing is now being abandoned. The object of the authors of this paragraph is obvious enough."

6. The frequent variations in the construction of locomotives serve to prove that the designers of six-wheeled engines, with outside framing, are convinced that their plan was not a perfect one: whilst, in this foundry, the same plan has been continued with which we began, and to which others are now coming round.

7. This being, in brief, the history of passenger locomotives up to the present time, we think it due to ourselves to give the reasons why we have so perseveringly adhered to our plan of engine with four wheels only, and inside frames, and we cannot do better than give the following compiled extract from a paper published in the transactions of the Society of Civil Engineers, and read before the society, March 17, 1840. It contains the statement of our opinions, of the soundness of which we had then had ample experience, and which still remain not only unchanged, but strengthened.

8. Next to a good boiler, which governs the economy of fuel, the most important point in the construction of a locomotive engine (inasmuch as it most materially influences the cost of repairs) is to connect all the parts firmly together by a strong and well arranged framing, so that they sha

tain their relative position when the engine is in motion, and that it shall receive and bear the strain, and the concussions to which every part is subject. The inside framing possesses a great superiority in this respect over the outside framing, as it forms a stronger and more direct connexion between the cylinder, the crank axle, and all the moving parts; and it bears all the strain of the engine, without throwing any portion of it on the boiler, as is the case with the outside framing.

9. These advantages are best described by comparing it with the ordinary outside framing submitted to the principal strains which it has to resist.

10. The most important is that caused by the whole power of the engine acting as a direct strain upon the crank as it passes over either centre.

11. With the inside framing the centre line of the connecting rod is only 10 inches distant from the centre line of the frame, and the total distance between the bearings is 43½ inches; but where the framing is outside the wheels, these dimensions are necessarily 20 inches, and 72 inches respectively; and the effects of the strain on the crank, in this case, would be, to its effect with the inside framing, as 14 is to 8.

"We have the *very remarkable* discovery announced, (says the Commentator,) that the nearer the points of support are to each other, the steadier the superstructure; and Messrs. Bury and Co. prefer a base of 43½ inches, to one of 72 inches! The statement of the 'effects of the strain on the crank' is erroneous, as all six-wheeled engines are, I believe, provided with inside framing to resist the strain of the cylinders."

12. For this reason, when the principal frame is placed outside the wheels, it becomes necessary to have an additional inside framing, to prevent the fracture of the axle. These additional inside frames not only cause an increase of friction on the bearings of the cranked axle, but also throw a considerable strain on the boiler, which then becomes the medium of connexion between the inside and outside frames, the inside frames being fixed at one end to the bottom of the smoke-box, and at the other end to the fire-box, while the principal frame is attached, by long brackets, to the body of the boiler.

"This paragraph (12) is strictly in keeping with the whole of the circular. The framing, both outside and inside of the wheels, in the four and six wheeled engine, is attached to the smoke box and the fire box, and also generally to the boiler. Messrs. Bury and Co.'s framing is, in my opinion, very defective in point of durability, and as a mechanical arrangement, inferior to any thing of the kind made by those persons who 'are convinced that their plan was not perfect.'"

13. The fact, that the use of four additional inside frames occasions six bearings on the axle, (that axle being only 6 feet long,) renders the system of principal outside framings so objectionable, that that circumstance alone should suffice to cause their rejection, for it is well known to practical men, that it is impossible to key so many bearings perfectly true, and to maintain them so when the engine is working; and even if this provision were attained, the aggregate friction on the four inside, and the two outside bearings, would be much greater than when it is all thrown upon two bearings; because, in the first place, all the friction due to the weight of the boiler is borne by the two outside bearings alone, and that which results from the pressure of the steam, through the medium of the connecting rod, is thrown upon the four inside bearings; the pressure on the outside bearings is vertical, and the mean pressure on the inside bearings is nearly horizontal. So that, if, instead of acting separately, these two amounts of pressure were thrown on the same bearings, the friction would only be due to the resultant of the pressures, and would, consequently be much reduced.

This (13) is denounced as a very "uncandid paragraph, if not something worse." "Messrs. Bury and Co. must be aware that not more than one or two frames at the most have been put into engines made within the last six years. I do not understand what can be meant by 'it is well known to practical men, that it is impossible to *key* so many bearings, &c.' It is not usual to key bearings. Whatever may have been *intended*, this paragraph is not likely to deceive any one in the smallest degree acquainted with the subject."

14. Another important feature is the strain to which locomotive engines are subject, from the pressing or striking of the flanges of the wheels against the rails, when travelling on a curve.

15. In engines with the bearings inside the wheels, the weight of the boiler has a tendency to bend the axle down in the centre, while the pressure of the

flange against the rail acts upon it in a contrary direction, and thus one strain counteracts the effect of the other. If the bearing is outside the wheel, the weight of the boiler tends to bend the axle upwards, and a strain on the flange of the wheel acting in the same direction and in addition to it, when the breakage of an axle takes place, these joint actions tend to force the wheels under the engine, and there being no flange on the outside of the wheel to prevent it, the engine is thrown off the rails, which, it is evident, cannot happen with an engine having inside framing, because the weight of the bearings presses the flange of the wheel against the rail, and assists the length of the journal in keeping it from falling or being thrown off the rails.*

"The introductory part of this paragraph (15) is not disputed, but Messrs. Bury & Co. in adopting inside framing, did no more than copy Mr. Blenkinsop, Mr. Stephenson, and many others. As to the concluding part, Messrs. Bury & Co. may consult the Private Journals of May last" (1842) "and the evidence given at a late inquest on the London and Birmingham Railway."

16. Several instances have occurred on the London and Birmingham railway, when an axle has broken, that not only have the wheels remained on the rails, but the driver has been able to proceed with the train to the nearest station.

"This admission is more than might have been expected, seeing that Messrs. Bury and Co.'s engines are *perfect*."

17. The stiffness of the single inside framing is not only a remedy against the excessive wear and tear which are consequent on a less perfect union between the parts of the engine, but its simplicity allows the whole machinery to be arranged in a more compact form, and constructed with greater solidity, with this additional advantage, that the engine driver, while standing on the foot-plate, can inspect the whole of the machine, and detect any derangement requiring his attention.

18. It is evident that the round form of fire-box possesses great advantages over the square fire-box: first, it is much safer than the square fire-box, being made nearly in that shape which an excess of pressure beyond its stiffness would tend to bring it to, if made in any other form; moreover, the safety of the boiler with a square fire-box is nearly dependent on the strength, individually, of each of the stays which is fixed in it, (of which there are a great number,) whereas the pressure in the round fire-box is borne equally by the whole area of the plates of which it is composed: again, the corners in the square fire-box, in which the combustion is always languid, and consequently injurious, are avoided in the round fire-box.

19. A lead plug is placed at the culminant point of the round fire-box, and will therefore melt before any other part is left dry, and, as the top row of tubes is placed two or three inches below the culminant point, it is almost certain that the extinction of the fire will prevent the tubes being burnt; but in a fire-box with a flat top, the melting of the lead would only occur when the whole surface was dry, and probably injured.

20. It is admitted that a locomotive engine should be as light as is consistent with great strength, simple in its construction, composed of as few parts as possible, and that the greatest regard should be had to the diminution of friction; it is thence obvious that four wheels must be preferable to six, provided they carry the engine with the same steadiness.

"The proviso at the end of this paragraph is a very important one, but it is not secured in the four wheeled engine, for if that has less friction than the six wheeled engine, why do the engines on the London and Birmingham railway consume more coke per carriage per mile than those on the Liverpool and Manchester railway? Eighteen months or two years ago, the difference was rather more than two to one, and is still very considerable."

21. The use of six wheels originated, (as we have before shown,) in the necessity of supporting the large and heavy fire-box, which was not sufficiently balanced by the smoke-box end; but no such necessity can exist in the locomotives made according to the accompanying plan, as the weight is nearly equally distributed on the front and hind wheels, and not only would the additional wheels be useless, but they would be prejudicial and dangerous when the engines are travelling upon curves.

* N. B. These effects are subsequently explained by the aid of diagrams.—Ed.

"This paragraph (31) commences with a misstatement, which has been already noticed. The London and Brighton Railway Company can speak to the latter part, as a man from Messrs. Bury & Co.'s has been two or three months putting a third pair of wheels (which were sent from Liverpool,) to each of the five or six engines made by the firm for that line, one of which engines, previous to the additional pair of wheels being put under it, caused a great loss of life not long ago."

A four-wheeled engine travelling upon a curve is driven, by the direct ication of the moving power, towards the outside of the curve; but, as the ls are rather conical, the large diameter of the cone will ride on the outside while the smaller diameter of the opposite wheel will bear on the inside rail, his difference, (as the outside rail is longer than the inside one,) will allow wheels to revolve without slipping or grinding.

"Another notable discovery in mechanics! Hitherto it has been always understood, that for the conical form of the wheels to produce the effect here described the axles must be rails."

With an engine upon six wheels, if the two leading wheels assumed this tion, the others would necessarily be dragged after them; but a still more rtant point is, that the angle which the centre line of the locomotive forms the tangent of the curve in which it is caused to move, is much greater six wheels than with four, so that the flange of the wheel presses more st the rail with the former than with the latter engine.

The pressure against the outside rail, arising from this cause, will be in proportion to the distance between the front and hind axle of either ne, so that it will be as 10 to 6.

"'Mechanicus' in the Railway Times, has shown the reverse to be the case. That the lateral motion of the four wheeled engine will bend the rails, was shown by the accidents on the Eastern Counties, and the Paris and Versailles Left Bank railways, where the rails were bent in a straight part of the line. I believe no instance has been known of a six-wheeled engine bending rails."

This pressure and consequent friction is still further increased by the of the middle wheel, which tends to ride on the same curve as the front hind wheels, but is prevented from doing so by being in a straight line en the two, and is thus forced to move laterally between the chord and cumference of the curve.

The friction arising from this lateral motion further presses the engine st the outside rail. Thus the four-wheeled locomotive has, in proportion, ater weight on the front wheels, it presses less against the outside rail, and much less friction when travelling on curves; hence, it has less tendency thrown off the rails, it is more simple in its construction, less expensive airs, on account of this simplicity, and the smaller cost of it fully justifies irectors of the several railways who have given the preference to this ption of engine.

"It is notoriously untrue that the four-wheeled engine has less tendency to be thrown off the rails than the six wheeled engine, as the Liverpool and Manchester, the London and Brighton, the Paris and Versailles Left Bank, and especially the Eastern Counties Railway Companies can well attest. Messrs. Bury and Co.'s engines are by no means as simple as the modern six wheeled engines, and cannot be kept in order at so small a cost. With reference to the original cost, if the statement of an Eastern Counties' director, in a letter published in the Railway Times about eighteen months back, may be depended upon, Messrs. Bury and Co.'s charge for a four wheeled engine with an iron fire box (for I understand they will make no other) was 50*l.* more than Messrs. Sharpe, Roberts, & Co. then charged for a six-wheeled engine of the same size with a copper fire box. The North Midland Railway Company can give some information concerning iron fire-boxes, as they have had to put copper ones in lieu of the iron ones made by Messrs. Bury & Co."

At the time the above paper was read before the Society, the four-wheeled had but few supporters, arising, no doubt, from the erroneous supposition, the safety of the engine was in proportion to the number of wheels used. It has, however, been steadily gaining ground in public estimation, and the alterations going on in the construction of the six-wheeled engine, the ters of them are evidently less confident in their superiority; and it is gratifying to us that the advantages to be gained by the use of inside g, which we then pointed out, are now tacitly admitted by our opponents greatest practical experience, who are gradually abandoning the outside

"Messrs. Bury and Co. acknowledge that the four-wheeled engine had but few ... in March 1840, but they say that since that time, it has been steadily gaining ground ... they should have said, *losing* ground. The public, including nearly all the engineers of the day, many of whom are clear-sighted men on other subjects, are unable to see the merit of four wheeled engines. The way in which Messrs. Bury and Co. here speak of ... framing, would lead persons unacquainted with the subject to believe that the out... framing is falling into disuse, but this is by no means the case."

29. As the inside frame becomes more and more general, the third pair of wheels will disappear, as not only useless, but really tending very materially to produce those accidents which they are supposed to guard against.

30. Indisputable proof has been furnished, that an engine with *inside frame* cannot come down by the breakage of an axle; an engine, therefore, is equally safe on that plan of construction whether on four, six, or eight wheels.

"Since the circular was published, three instances at least have occurred, of four-wheeled engines having come down after the breaking of the front axle, by which accidents, taken collectively, it is believed more than one hundred lives have been sacrificed."

31. The advantages of four-wheeled engines, on our plan of construction, we maintain to be the following: 1st. The engine on four wheels is less costly than the one on six wheels; therefore to have the same number of engines, of the same power, on a line of railway, much less outlay of capital is required.

"The four-wheeled engine ought to be less costly than the six-wheeled engine, but hitherto, I believe, that has not been the case. An additional number of inferior engines, of equal nominal power, will be required to compensate for the smaller power of each, arising from that inferiority, as may be seen on the London and Birmingham and Grand Junction railways. The London and Birmingham Railway Company employ two engines to draw such trains as are drawn at full as high a speed by one engine on the Grand Junction railway, although, on the latter line, the engines are what are now called small."

32. 2d. It allows the engine to be got into less space, consequently it is more compact, firmer, less likely to derangement, and much lighter.

"The four-wheeled engine is, on the contrary, generally six inches, and often nine inches longer than the six-wheeled engine."

33. 3d. Though the engine is lighter, the adhesion is more perfect, from the weight on the driving wheels remaining nearly uniform, however unequal or out of level the rails may be; but in the engine with six wheels the adhesion is often imperfect (arising from the impossibility of mathematical precision in maintaining rails on the level,) although there may be fully as much weight on the driving wheels generally; that is, the fore and hind wheels sometimes carry the greatest part of the engine. When the driving wheels get into an uneven part of the road, and the constant action of the power of the engine is not resisted by the adhesion at these points, the driving wheels revolve without properly advancing the train, as every observant traveller knows; and all weight carried beyond what is necessary for adhesion on the rails, is an unprofitable load. There is much less of this in the four-wheeled than the six-wheeled engine, seeing that there is only one pair of wheels used for adhesion both in the four and six-wheeled engine, when used for passenger traffic; but, as the four-wheeled engine is lighter than the six-wheeled engine, there is less power required to take it up the inclines, and therefore more available power left applicable to the traction of the train.

"The assumed superiority of four-wheeled engines would be more readily believed by railway proprietors, if Messrs. Bury and Co. would convince them that a greater amount of traffic can be done with the same number of four-wheeled engines and weight of fuel than can be done with six-wheeled engines."

34. 4th. The engine is safer, as it adapts itself better to the rails, not being so likely to run off the line at curves or crossings.

"'*At curves or crossings*,' but what at the *straight* parts? The greater liability of four-wheeled engines to run off the line in straight parts, is a fact incontrovertibly established by the experience of the Eastern Counties, the London and Brighton, and the Paris and Versailles railways."

35. 5th. It is more economical in the working, requiring less fuel, there being also a less amount of depreciation, as there are fewer parts in motion, consequently, less friction, or wear and tear, and fewer parts to maintain; and even those are more easily got at, therefore much less expense is incurred in those repairs which are common to both plans.

"Every point in this paragraph is just the reverse of the truth."

36. 6th. The buildings, turn-tables, lathes, drills, smithies, and other costly conveniences necessary for the maintenance and repair of the engines, are not required on so large and extensive scale, as the engine on four wheels is less in size than the one on six wheels.

> "The whole of this is at variance with facts, except so much as refers to the size of the turn-tables."

37. 7th. As the engine is more simple in its form and parts, there are fewer chances of delays, stoppages, and disappointments during the journeys, or the times of taking the trains.

> "Whatever the 'chances' may be, what are the facts! Not only have the greatest number of accidents happened with four-wheeled engines, but those accidents have been among the most disastrous that have occurred."

38. Whilst, therefore, those individuals who have advocated the use of the six-wheeled engines are constantly changing their ideas, at one time adopting a large fire-box with the outside frame, and the addition of a third pair of wheels behind the heavy box to carry it, then changing to the small fire-box, with the third pair of wheels placed before it, and, subsequently, by the tardy adoption of the inside frame; we have been steadily persevering with our original plan, of engines on four wheels, which is now brought to a state of perfection for power and economy far beyond anything we could have expected. In proof of this, we can confidently refer to the London and Birmingham, the Eastern Counties, the Midland Counties, the North Union, the Lancaster and Preston, and the Manchester, Bolton and Bury railways, which are worked exclusively with the form of engine we have adhered to; and also to the Edinburgh and Glasgow, Glasgow and Ayr, and Runcorn Gap and St. Helen's, and several other lines which have in part adopted it.

39. In justice to ourselves we have thought it right to lay these remarks before the public, at the same time that we are quite ready to construct engines upon six, or any other number of wheels, freeing ourselves from the responsibility of the consequence of any other plan than our own; and only requesting that such of our friends and the public as may entrust their orders to us will permit us at least, for the safety of travellers, and our own credit, to adhere to inside framing.

Bury, Curtis, and Kennedy.

> "It appears from this, that the four-wheeled engine 'has been steadily gaining ground,' until Messrs. Bury and Co. have discovered that it would be more profitable to make six wheeled engines than—to close their works." February 2, 1843

We were unwilling to interrupt the continuity of the foregoing controversy by any remarks of our own, as they would perhaps have caused some confusion as to their authorship; but we will now briefly observe, that some parts of the replies of the "Practical Engineer" are somewhat irrelevant to the subject, and of no public interest; which would have been avoided, had Messrs. Bury and Co. expressed themselves with more discrimination as to the origin of the particular arrangements of construction they alluded to. For our own parts, we never for a moment supposed that those gentlemen meant to lay a claim of invention to *four-wheeled* engines, or to *inside* framing;—because it must have been notorious to the most superficial observers, that those modes of construction were more extensively adopted than any other, in the early locomotive engines. But we regarded the observations in their circular, which gave rise to the animadversions of the "Practical Engineer," merely as a defence of those arrangements which long practical experience in manufacturing for the most successful line of railway in the kingdom (where they have been undeviatingly used), had led them to consider the best: and which circumstance, we may add, has earned for them a high reputation as practical engineers.

We shall here annex Messrs. Bury and Co.'s diagrams, explanatory of the effects of inside and outside framings in the case of a broken axle, alluded to in the preceding circular at page 462.

Fig. 1.

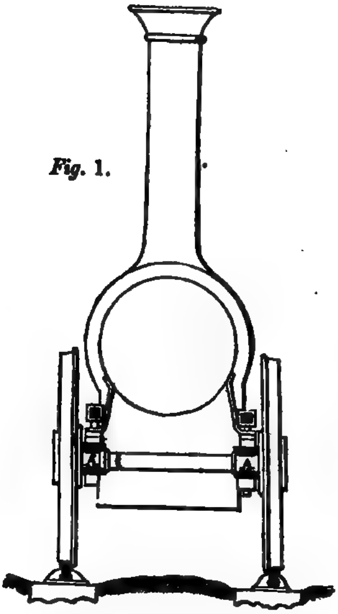


Fig. 3.

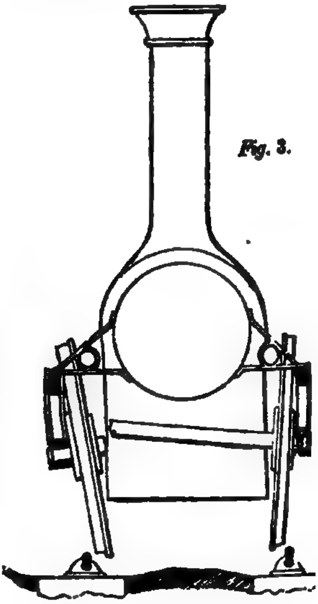


Fig. 2.

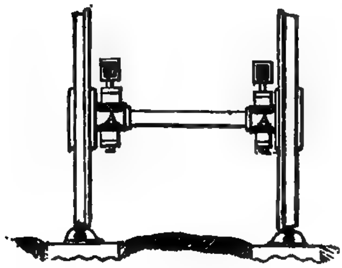
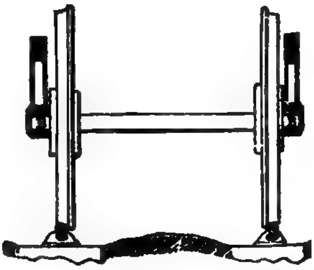


Fig. 4



Explanation of *Figs.* 1 and 2. In this Engine the bearings are inside the wheels, and the weight of the engine and boiler is carried at A A. The tendency of the axle therefore is to bend downwards in the centre, whilst the pressure of the flange against the rails in going round curves has a contrary tendency. Thus, one strain counteracts the effects of the other; and, if the axle breaks, the wheels can spread out no farther below than the amount of allowance for play between the flange of the wheel and the rail. The wheels therefore being confined between the rails by the flange pressing against the inside of the rails, may proceed with safety to the next station.

Explanation of *Figs.* 3 and 4. The gravit insistent weight of this Engine with side frame, is carried at B B outside wheels. The gravity of the entire eng and boiler in this case, tends to bend axle upwards in the middle, and pressure of the flange of the wheels aga the rails in going round curves, acts in same direction, and in addition to This continued bending of the destroys the fibre of the iron, and mately it breaks; and when it is brok the tendency of the axle upwards, before shown, forces the wheels betw the rails, there being no outside flang prevent it, as is shown in *Fig.* 3.

Had we space to go into the subject at large, we could show by referenc authentic official documents that "A Practical Engineer" has commit himself on several points, but we have only room to admit a short lett

addressed to the Editor of the Mechanics' Magazine, signed J. G. S. (vol. xxxvii. page 246,) which completely disproves the assertions of the before mentioned gentleman on some very important points. The letter states, "Your correspondent, the 'Practical Engineer,' asserts, that the engines of Messrs. Bury and Co. on the London and Birmingham railway, consume more coke per mile per carriage, than those on the Liverpool and Manchester. He also says, that, on the Grand Junction railway, one engine is employed to draw a train of equal weight, and at an equal speed, to one which on the London and Birmingham requires two engines. Now, the annexed tables will show the *opposite* to be the case on the Grand Junction; and from Time-tables in Pambour's Treatise on the Locomotive Engine (pp. 312, 313) I find the average quantity of coke consumed on the Liverpool and Manchester to be about the same as on the Birmingham, though in no case does it average so low as 29lbs. per ton per mile, as in the annexed tables. The 'Practical Engineer' says also, that in his opinion, Messrs. Bury and Co's. inside frame is very defective in point of durability. Perhaps he will give his *reasons* for thinking so, and show the advantage of the heavy outside framing of wood.

"J. G. S."

EXPERIMENTS ON THE GRAND JUNCTION LINE.

Name of Engine.	Date.	Gross Load in Tons.	Mean Speed in Miles.	Coke per Mile in lbs.	Coke per ton per mile.
PHALARIS	May 30, May 31, June 1, June 5	59.2	23.05	37.03	·62
PROMETHEUS	June 5, June 6, June 7, June 8	54.7	22.53	34.3	60
PROMETHEUS	June 11, June 12, June 13	52.8	22.30	41.9	·79
PHALARIS	June 14, June 15, June 16	62.6	22.06	38.5	·61

EXPERIMENTS ON THE LONDON AND BIRMINGHAM LINE.

Descriptions of Engines.	Gross Load in Tons.	Mean Rates.	Coke per ton per mile.
Twelve inch Cylinders and 5 feet Wheels	50.13	30.51	·47
	70.95	28.53	·43
	81.61	21.86	·35
Twelve inch Cylinders and 5 feet Wheels	50.77	31.29	·53
	69.76	29.82	·41
	83.53	19.42	·29

Ascending of Inclined Planes.—One of the chief difficulties in the application of locomotive carriages to railways has been to obtain sufficient friction or adhesion between the driving wheels and the rails to cause them to ascend planes of considerable inclination, as the wheels are in such cases apt to be turned round without advancing the carriage. To prevent this, Messrs. Vignoles and Ericsson, by their patent of 1830, proposed to introduce a third or friction rail between the two bearing rails. This friction rail consists of a flat piece of iron extending along the middle of the road, and securely fixed in a vertical position, as represented in section in the annexed figure. On each side of this friction rail, which is made of considerable depth, is placed a horizontal friction roller, as shown at *c*, *d*; the roller *c* being made considerably larger than *d*, and fixed upon its vertical shaft *e*, while *d* is permitted to turn freely on its vertical shaft *f*. On the driving axis *g* is fixed a bevel wheel *h*, which turns another bevel wheel *i*, fixed upon the vertical shaft *e* of the driving roller *c*. The bearings of this driving roller and its shaft are firmly fixed to the under side of the locomotive carriage by the block shown at *k*, and the bearings of the friction roller *d* are hinged to the block at *l*, that it may at pleasure be pressed against the friction rail *a*, by the lever *m*. This lever is wrought by bringing it within reach of the engineer or his assistant, who, acting upon the

..roller *b* is attached; *c* is the metallic case to the trench; against the ..f which the roller is intended to act, as the carriage travels along, the ..s of which are restrained from running off the rails, by the flanges *d d* not ..tting the carriage to rise.

Fig. 1.

Fig. 2.

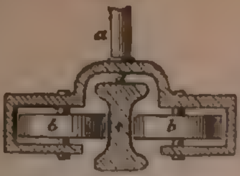
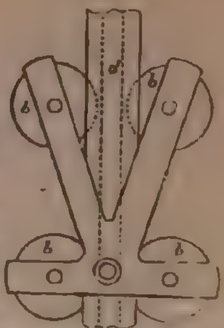


Fig. 3.



... 2 and 3 are explanatory of the other mode men-... At *a* is the vertical arm; *b*, *b* the anti-...n rollers acting against the sides of the middle ... as the carriage proceeds, the broad top *d* of the ...ail keeping the rollers in their places and pre-...g the carriage from rising. For the better ...nce of the carriage in its true course, there are ...two pair of rollers *b*, *b*, placed at a short distance one before the other, ...ounted in a frame of the kind delineated in the annexed *Fig.* 3.

...e patentee appears to be aware of the paucity of originality in his scheme, ...nfines his claim to invention in the application of the "top flanges, to ...t the carriage rising."—*London Journal, for July*, 1841.

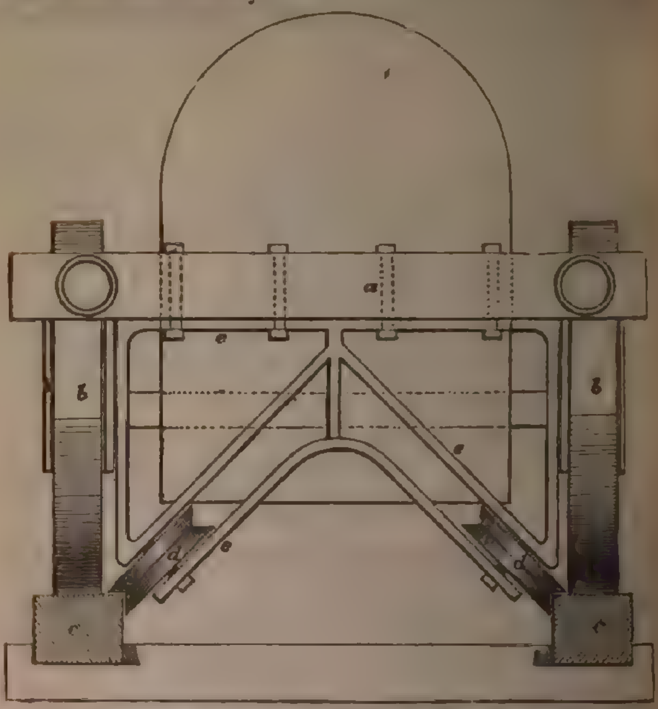
...sser's Guide Wheels and used in railway.—In 1844 Mr. W. Prosser ...ed a patent for "Improvements in the construction of railways and in ...ges to run thereon;" the latter improvement consisting in the removal ... guiding flanges from the periphery of the bearing wheels, and substi-... for them a peculiar arrangement of guide wheels attached to the frame ... carriage. These guide wheels were devised chiefly with reference to Mr. ...r's improvements in the construction of railways, in which he proposed ...titute for the iron rails, continuous bearings of solid Kyanised timber.

... as these guide wheels are applicable on railways of the ordinary construc-...and as the arrangement appears to exhibit considerable ingenuity, and to ... much practical merit, we subjoin a short description of it. We may ...e that the idea of employing guide wheels instead of flanges on the bearing ... to keep the carriages on the rails is not new; indeed we have in the ... of this treatise noticed several plans for this purpose, but we believe that ... previous arrangements a third or additional rail was required for the ... to act upon; whereas in Mr. Prosser's plan no additional rail is requisite· ... guides act upon the bearing rails, and possess this great advantage, ...in the event of breaking of an axle they would support the carriage and ... it to continue its course.

... end view of a locomotive with these guide wheels attached is given in ...llowing engraving.

... is the engine frame, *b*, *b* the bearing wheels, *c*, *c* the wooden longitudinal ...rs before mentioned; but for which may be substituted the ordinary iron ... *d*, *d* are the guide wheels turning upon pivots in a frame *e* attached to ...d of the frame of the engine. These wheels are placed at an angle of ...ith the horizon, and have an angular groove in their periphery, one face ... groove being horizontal, or parallel to the surface of the rail, and the ...face being vertical or parallel to the side of the rail. The distance between ...guide wheels is a little less than the distance between the rails, so that when ...arriage is proceeding in a straight direction the guide wheels do not come ...tact with the rails; but when the carriage deviates to one side, the guide ... on that side are brought immediately into action, and prevent further ...tion.

Mr. Prosser's rails and wheels have, we believe, been adopted on the Guildford and some other lines of railway.



Stephenson's Compound Axles.—In the specification of a patent granted to Mr. Robt. Stephenson in 1831, he informs us that in the carriages previously used on the Manchester and Liverpool railway, each pair of wheels was fixed fast on the two opposite ends of a long solid axis, which revolved with the wheels, and the two extremities of the solid axis, which projected through the centres of the wheels, were formed into pivots or gudgeons and were received into suitable sockets, whereon the weight of the carriage was borne by the concavities of those sockets pressing downwards upon the pivots. In travelling with great rapidity, the said pivots required a copious supply of oil, and much of it was wasted, because the concavities of the sockets being inverted, the oil had a tendency to run down and escape from the places of bearing where it was wanted. According to the improvement of 1831, Mr. Stephenson's plan consists in fixing the pair of carriage wheels fast upon the extreme ends of a long hollow, or tubular axis, within which a solid central axis is inserted, extending through all the length of the hollow, and projecting out sufficiently beyond each of the hollow axes to enable the weight of the carriage to be supported upon the projecting ends of the solid central axis, around which the hollow axis turns, together with the two wheels, which are both fastened upon the ends of the hollow axis, to prevent one wheel from advancing either faster or slower along one rail than the other wheel advances along the other rail.

In the subjoined figures—*Fig.* 1 represents a vertical section through the centre of the wheel to show the novel arrangements of the parts, and *Fig.* 2 a side elevation of the same.

At *a a a* is the solid axis, enlarged at *a*, *b* is the tubular axis, passing through the central boss *c* of the wheel *d d*, and bolted to the same as shown at *e e e e*.

rough a circular plate *f* front. The weight of the carriage is supported at *g g* the projecting part of the axis *a*; which is received into a solid metal socket made in two halves, and screwed together by four bolts *i i*, and two staple

Fig. 1.

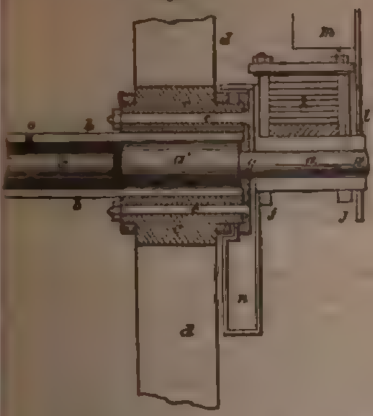
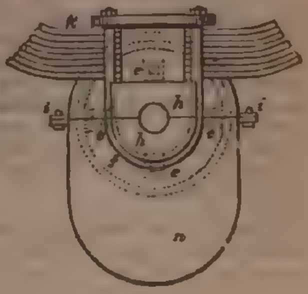


Fig. 2.



lts *j j*, which fasten the springs *k* down across the upper flat sides of the cket *h*; thus the two halves of the socket are bound firmly together by the d screws around the end *g* of the solid axis, and secures them together. The er end of the socket *h* is fitted into a vertical groove formed in the space ween the prongs of the guide plate *l*, which is screwed to the horizontal side *m* of the carriage, as shown in *Fig.* 1, and projects downward therefrom. he oil is supplied at an aperture *o*, provided with a screw plug, and finds its y between the rubbing surfaces of the axis, and the portion that escapes past e bearings is received into an oil box *n* of cast iron, made in two halves for ing it on to its place.

Losh's Patent Railway Wheels.—Some improvements in the construction of eels for railway carriages were patented on the 31st of August, 1830, by Wm. Losh, of Bentom House, in Northumberland, a gentleman whose perience and knowledge in matters of this kind entitles his suggestions to the ention of the public.

Fig. 1.

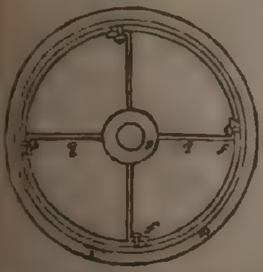
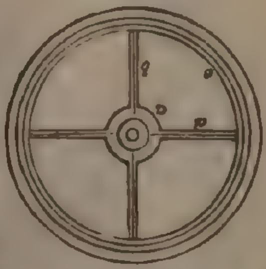


Fig. 2.

Fig. 3.

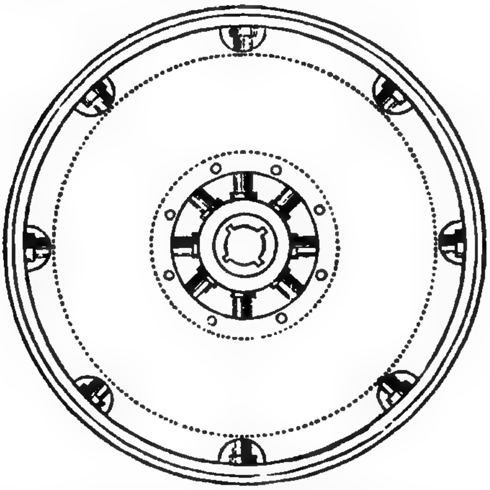


he nature of this invention will be at once understood from inspection of 1 and 2, where *a a a a* represent the tire and flange of a wrought-iron ay wheel; *b b b b* spokes which are to be made dove-tailed at one end, and nto the nave *c*, as shown in section at *c c*, *Fig.* 2. The other end of the

spoke has a right angular crank bend, as shown at *f f f, Fig.* 1; being round the circle to the next spoke; and thus each spoke and its a felloe are made of one piece of iron. By means of the crank bend at of the spokes, one felloe is permitted to pass over the end of another, this double part they are securely fixed together by strong screws, as sh dotted lines. The tire is formed (in passing finally through the roller iron works,) with a recess for the felloe, and a flange to keep the on the railroad, as represented at *a a*; and it is to be heated and fitted wheel in the usual manner, that it may contract and firmly grasp th when it contracts in cooling. The ends of the spokes, too, must be m before the nave is cast upon them, that the junction of the two metals the more perfect. It is stated that it may be sometimes found more co to weld several pieces of iron together than to bend one piece twice angles. It is likewise stated that the spoke may be sometimes with ad welded on the middle of a piece extending along a ring constituting th in both directions.

Lessening the vibration and noise of Railway Wheels.—It is now g understood that the rapid deterioration as regards the strength of wheels and axles, is chiefly caused by the intense vibration to which subjected. This can readily be made evident:—if the journal of an old axle is struck with a smith's hammer, it will in many cases break off single blow; presenting at the fractured part a weak brittle appearance; the journal of a new axle will take several hundred blows before b a tough fibrous appearance being presented at the fractured part.

Mr. Lipscomb's apparatus for preventing the vibration of wheels simple, and we believe efficacious. It has been applied, we understand of the Royal carriages on the Birmingham and London railway. It of a plate of zinc placed on each side of a wheel, for the purpose of re saw-dust in contact with part of the rim and spokes; each plate has two rings of unequal size permanently fixed to it; the external diameter



smaller ring, and the internal diameter of the larger ring are circles in the annexed figure, and are likewise flush with the plates. The combined depth of the corresponding rings is e the tyre; these rings meet and are screwed together, certain being cut away to let in the spokes. By a reference to the

so that the ends of the spokes, adjoining the nave and tyre, are left exposed for the purpose of noticing any defect which may take place in those parts.

The apparatus may be detached from the wheel, by simply taking out the screws which hold the corresponding rings together, and is applicable, with slight modifications, to all existing metal wheels. The cost of the apparatus is 1*l* per wheel, and it will last for many years.

Wheels formed of a combination of wood and iron are in partial use upon some railways for the purpose of decreasing noise and vibration, which still exist, notwithstanding, to a very considerable extent.

Dircks's Wheels.—At the meeting of the British Association at Glasgow in 1840, Mr. H. Dircks exhibited a wheel of a novel construction, invented by him, which had been running for several weeks on the St. Helen's railway with very satisfactory results. The construction of the wheel will be understood by imagining an ordinary spoked wheel, but with a deep channelled tyre, as seen in *Fig.* 2. In this channel are inserted blocks of African oak, measuring about 4 in. by 3½ in., prepared by filling the pores with unctuous preparations, to counteract the effects of capillary attraction in regard to any wet or dampness, by which it becomes impervious to either. There are about 50 of these blocks round each wheel, cut so as to fit very exactly, and with the grain placed vertically throughout, forming a kind of wooden tyre, each block being retained in its place by one or two bolts *Figs.* 3 and 4, the two sides of channel having corresponding holes drilled through them for this purpose. The bolts are afterwards all well riveted. After being so fitted, the wheel is turned in a lathe after the ordinary manner of turning iron tyres, when it acquires all the appearance of a common railway wheel, but with an outer wooden rim, and the flange only of iron. Mr. Dircks proposed using either hard or soft woods, and various chemical preparations to prevent the admission of water into the pores of the wood; he also contemplates the using of compressed woods.

Fig. 1.

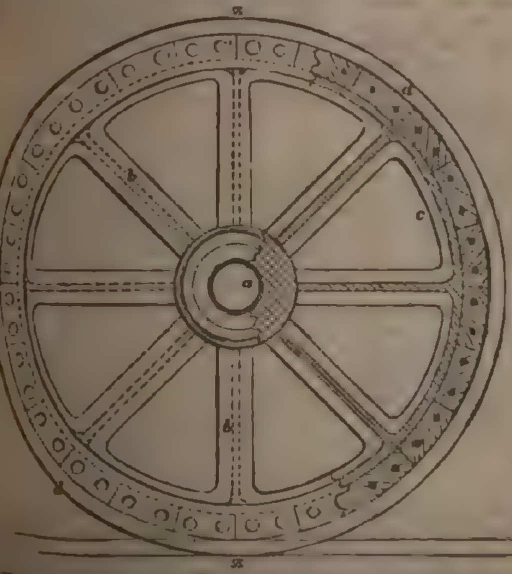
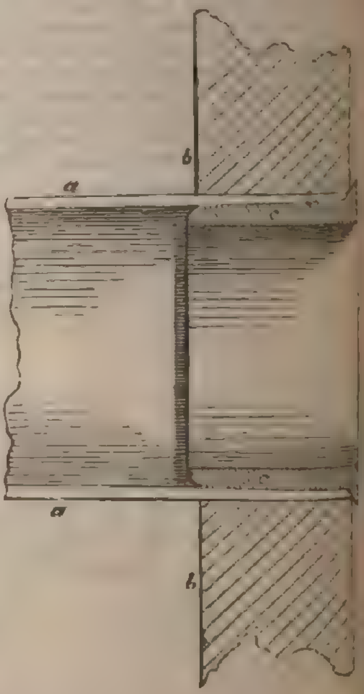


Fig. 2.

The annexed figures represent one of these wheels, *Fig.* 1 being a front elevation, (partly in section,) and *Fig.* 2, a vertical section through the line Z.

a is the boss; *b b* the arms; and *c c* the rim or felly of the wheel, having deep flanches *d d* on each side, forming a circular groove or trough round the periphery of the wheel. In this groove or trough are inserted the blocks of wood *e e* (before mentioned), which are retained in their places by bolts *f f* passing through them, and riveted outside the flanches. The several advantages which this wheel possesses, are represented by him to be,—that the wooden tyre will wear a considerable time without requiring any repair; that the tyre can be refaced by turning it up again in the lathe, as practised with worn iron tyres; that it can be re-tyred with wood at little expense, and at a far less loss of time than usual; and that both in the operations of refacing old tyres, or putting on new wood, the work can be performed without the usual labour and cost of unkeying, as the whole can be done while the wheels remain on the axles. One very important advantage yet remains, and that is, that the rails themselves will suffer less wear by using these wheels, and the fastenings, sleepers, and blocks, not be nearly so much injured.

Mode of fixing tubes in locomotive boilers.—These tubes are made of the best rolled brass, one thirteenth of an inch thick, the edges of the brass are properly chamferred, and lapped over each other, and soldered together, the solder being applied inside; the tubes are then drawn through a circular steel die, to make them truly cylindrical. The holes to receive them in the tube plates *e* and *n*, are bored quite cylindrical, so as to fit the tubes exactly, which are just long enough to come to the outside of both plates; the ends of the tubes are then fixed by driving in a steel hoop or ferrule made slightly conical, as shown in *Fig.* 1, which is a section full size of the tube *a a*, the plate in which it is inserted, and the ferrules *c c*; the ferrule is a little larger than the tube, so that when driven in, it compresses the tube very forcibly against the sides of the hole, and makes the joint completely watertight. The ferrules are sometimes made of wrought-iron, but they generally do not last out the tube in that case, and require replacing by new ones before the tubes are worn out. The steel ferrules are better, as they last nearly twice as long. When a tube or ferrule requires taking out, the ferrule is to be cut quite through with a chisel and then turned inwards, so as to detach it from the tube, which can then be driven out.



Water Gauge.—In order to show the height of the water in the boiler, two methods are employed; the first consisting of a number of gauge cocks fixed at 2 or 3 inches apart, one over the other, by turning which in succession, the engineer ascertains whether they are open to water or steam: the other is by an instrument called the water gauge, which consists of a strong glass tube *a*, about three quarters of an inch diameter outside, fitted into a brass socket

p and bottom, the joints being made steam tight by hemp packing nd the glass, and compressed against it by the glands *c c*, which are n round the glass. From each of the socket s a tube *d* proceeds with a cock in it, and a n the end, for fixing it into the fire-box, and the ntaining another cock is screwed into the lower nd the plug *f* into the upper piece, affording ns of putting the glass tube down into its place. he two cocks in *d d* are opened, the water of r rises in the glass tube to the same height that the boiler, the upper part of the glass being th steam, and so remains, shewing always l of the water in the boiler; the cocks are urpose of stopping the communication when from the gauge being out of order or other- The cock in the piece *e* is for the purpose of out the gauge, by allowing a stream of water rough it, and it is often necessary to open it amining the gauge, in order to get rid of les of steam formed by the rapid ebullition ater, which sometimes render it difficult to the precise height of the water. The difficulty creased by the motion of the engine, pro- scillation in the water, but the disturbing much diminished by choking the tube or he communication with the boiler through d very small, so as to impede the motion of in the tubes. A small plug *g* is screwed in ach tube *d*, to afford the means of clearing tubes *d*, by passing a wire through them plugs *g* are taken out.

y's water ash-box.—Instead of the ordinary , which is usually suspended below the furnace, purpose of receiving the falling cinders, ng employs a shallow tank containing three or four inches depth of pplied from the tender by means of a pipe and stop-cock. The falling and the radiating heat from the furnace, consequently heat the water nk, which, being returned into the tender, raises the temperature of the rein, and effects an important saving of fuel. To render this operation , the boiler is furnished with a ball valve, loaded with 50lbs. on the h, so that at such pressure the steam will escape and pass into the k, and become condensed. By this arrangement, the boiler may be pplied with water at or near the boiling point.

s are strong elastic cushions, placed at each end of the carriage, con- ith a system of springs, to deaden the effects of concussion. They ly constructed.

llowing *Fig.* 1 represents a side elevation of one of the Dublin and n railway carriages, with Mr. Bergin's invention applied to the same. plan of the under part of the same, the body being removed. *a a* a slight frame, made of two similar plates of iron, screwed to each t three inches apart, and resting upon turned bearings in the centres s. A wrought-iron tube *b b*, about three inches in diameter, the gth of the carriage, and extending about two feet beyond each end, d on this frame by rollers, which allows the tube to be moved thereon s with facility. On this tube is placed, at either end, within the frame rriage, about four feet of helical springs *c c*, of graduated strengths; each of these sets of springs abuts against a strong collar *d*, fixed to , and the other end against a small box of iron attached to the frame,

and furnished with one of the bearing rollers before mentioned, also with two friction-rollers resting against the inner side of the carriage-frame end. To each extremity of the tube *b b* is attached a buffer-head *f f*, by means of a rod of iron passing through the tube, and connected to the buffer-heads by screwed nuts sunken below their surfaces. At the back of each buffer-head is a cross-bar *g*,

Fig. 1.

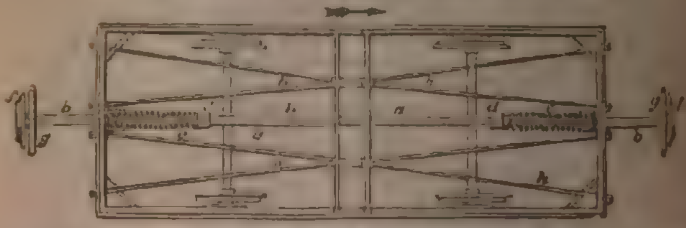


Fig. 2.

to which, by chains and hooks, the carriages are attached together. This apparatus lies loosely on the axles, and is perfectly independent of the frame-work of the carriage, which is sustained by springs in the usual manner; and there are long vertical slots made in the framing, through which the buffing-tube passes, which permits the frame to rise or fall, according to the pressure of the load thereon, without affecting the height of the buffing apparatus above the road.

The action is as follows:—The train being moved in the direction of the arrow, the locomotive power is applied to the cross-bar *g*, and draws forward the central tube *b*, thereby compressing the springs *c c* between the collar *d d* and the friction roller box, which rests against the end of the carriage frame, without moving the latter, until the elastic force of the compressed springs becomes sufficient to overcome the resistance presented by the friction of the carriage and load. The carriage then begins to move forward, so slowly as almost to be imperceptible to persons seated within; the second and each succeeding carriage in the train is by similar means brought from a state of rest into motion. In case of one carriage running against another, the resistance is offered by the furthest end; the effect being to drive the tube *b* forward, compressing the springs at the opposite end from which the concussion is given, and the carriage will be but little affected by the blow, until the elasticity communicated to the springs by compression overpowers the resistance of the carriage, which then begins to move, actuated by a force just sufficient to start it. The coiled springs have a range of action of about two feet, beginning to be compressed by a force equal to about twenty pounds, and presenting a total resistance to entire compression of upwards of two tons. A spring of this strength, the patentee states, has been found suitable for carriages weighing, when loaded, about four tons. It will be observed, that the entire resistance to the action of the springs is on the ends of the carriage frame; the

of each is armed with a strong plate of iron, about fifteen inches square, which pass the tension rods, *h h*, *Fig.* 2, to the outer angles of the le ends of the frame; consequently, the rods receive the entire force of ings. The springs at either end of each carriage act totally independent at the other end, and of all the carriages in the train, except that to hey are attached; each has, therefore, to bear only its own share of the ce of the entire train, the sum of which is made up of the separate ces of all the springs acted upon.

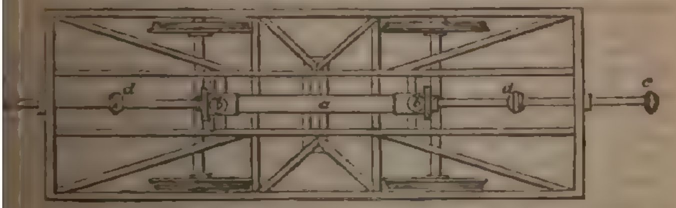
tt's Buffers.—Robert Mallett, Esq. of Dublin, in a communication to or of the *Mechanic's Magazine*, has described an ingenious and original buffing, an extract of which we shall proceed to give. Mr. Mallett s;—" The employment of elastic fluids to serve as springs, has been tly proposed, and occasionally brought into practice, but never upon a ale, or with very successful results. This has arisen, principally, from that it is impossible to make any cylinder and piston, or any rod and box, absolutely and permanently air-tight, especially under the effects n and violent compressions: hence, the air, or other elastic fluid used, ays been found gradually to escape from the vessel provided for its ssion, leaving the whole apparatus springless.

et, if this difficulty be once overcome, the advantages accruing from the air (as the most available elastic fluid we have) as a spring, are reat.

remains a spring at all temperatures, and in all climates; and its properties h, that the resisting energy of the spring increases with the amount of ce with which it is compressed or urged, and, by a suitable arrangement, made to increase according to any assignable law.

y method of overcoming the one great obstacle to the use of air as a spring in confining the air to be compressed by a body of water, or other and is based on the well known fact, that joints or sliding surfaces can

Fig. 1.



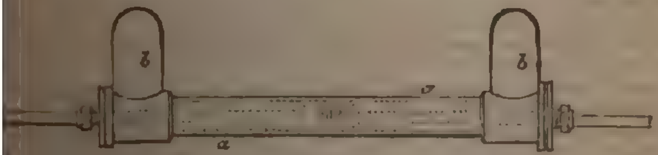


Fig. 2.

be made *water-tight*, and kept so, which cannot be made or maintained.

the month of February, 1836, I designed a set of buffing apparatus upon , which was constructed by the firm with which I am connected, and on the Dublin and Kingstown railway, attached to one of the open r carriages. *Fig.* 1 shows a plan of the under carriage, fitted with the apparatus; and *Fig.* 2, a side view of the air cylinder, &c. on a larger

scale. The system of *thorough* buffing, as invented by Mr. Bergin, the intelligent manager of the railway, is in use upon the Dublin and Kingstown line, and hence was adopted in the hydro-pneumatic buffer, as then designed. *a a*, is a truly bored cylinder of cast-iron, closed at each end by a cover, provided with a large gland or stuffing-box, through which the buffer rod passes, being turned truly like a piston rod, which, in fact, it is. The buffer rod, going from end to end of the carriage, passes right through the cylinder, and carries a solid piston, packed with leather collars and pressed leather caps, which when in a state of repose is situated in the middle of the length of the cylinder. *b b* are two air vessels of a cylindrical form, with hemispherical ends cast on to the cylinder, and standing vertical upon its upper side when *in situ*. The capacity of each air vessel is equal to that of half the cylinder, minus the bulk of the piston and included portion of buffer rod. The diameter of the cylinder was 6 inches, and that of the buffer rods 2½ inches of solid iron. By means of a suitably situated screw plug, the whole of the cylinder was filled quite full of water, leaving the two air-vessels above it full of air, which by a condensing syringe, was brought to a density of one additional atmosphere, or to about 15lbs. per square inch, plus pressure.

"In this state of things, it is obvious that any force acting at one end of the buffer rod would compress the air in one air vessel and rarify that in the other by carrying the central piston rod towards one end of the cylinder, and thus driving the water at that end up into the air vessel. It is also plain that, as the water will always remain at the lowest part of the vessel, it will be constantly interposed between the air and the only possible places of escape from the cylinder, namely, the end covers and stuffing boxes. The range of the buffer rod was limited to two feet—a limit, however, which it is scarcely possible it could ever reach by any force, as the air would then be condensed into about one-fiftieth of its original volume; but as a further precaution the buffer heads *c c*, and the counter buffer-heads *d d*, were so arranged, that, at the extremity of the range any shock given to the buffer-rod would be visited upon and distributed through every part of the frame of the carriage. The whole buffing apparatus was secured by bolting to the frame of the under carriage, to which it became a firm and substantial spine or back-bone, as it were, increasing its strength, in place of breaking it.

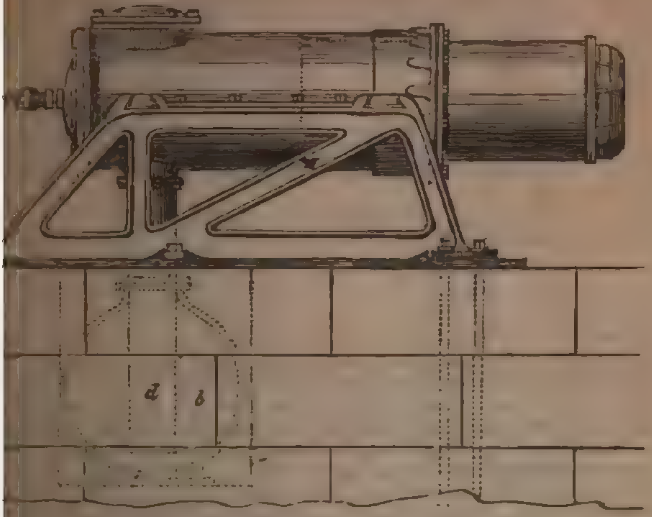
"The very first experiment made with this buffer, on the Dublin and Kingstown railway, consisted in bringing the carriage upon one of the lines, and causing 10 or 12 of the railway porters to run it, as fast as they could, full tilt against one of the stone walls of the station house, from which it rebounded, uninjured, like a piece of Indian rubber. The piston was not nearly driven home, or its whole range, but had passed through more than four fifths of it, indicating a blow equal to more than 1500 lbs. The carriage was then connected with a locomotive engine, and drawn along the line, going at various speeds, stopping and reversing as suddenly as possible. The results were in every respect satisfactory."

The before-described buffer continued in use as long as the under carriage lasted. About four years afterwards Mr. Mallett designed two improved forms of air buffers; one of them being intended for a great terminus buffer, to be placed in a station house or other similar situation, where trains require to be brought up without the possibility of running beyond a given point.

Page 479 is a side elevation of such a buffer. The construction is so simple as scarcely to need description. A large cast-iron cylinder, having a gland at one end, and closed at the other, is firmly secured down in a horizontal position on a mass of masonry, by lateral framing of cast-iron on a bed plate; the gland of this is filled by a turned cylinder of cast-iron, also hollow, bore of 36 inches diameter, open at its inner and closed at its outer end, which is armed with a large padded leather buffer-head. This cylinder is free to slide in the gland horizontally. The outer cylinder has at its lower side a large aperture communicating with a spherical air vessel *b*, by a pipe *d* dipping into it; this enclosed in a cavity of the masonry.

"This cylinder is filled with water, simply by pouring in at the top man

then screwed down, and the buffer is ready for use. The air in the ls, which is here of about equal capacity with the cylinder, is of course ntly compressed with a force equal to a column of water of the from the surface of the water in the air vessel to the highest part of the



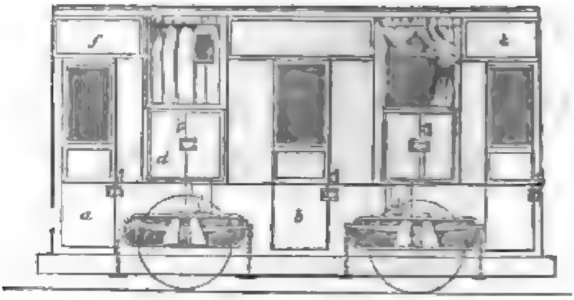
and if any impulse be given to the inner cylinder, which may be ed simply as a large plunger or ram, it will be driven forwards into the linder, and in doing so will drive an equal bulk of water into the air mpressing the air therein, the elastic resistance of which will increase tion to the compressing force.

is buffer, if the plunger be driven in half way, the air in the vessel will nsity of one atmosphere, and the total resistance afforded at this point 15,270 lbs. and so on; and if the plunger were driven in so far that pheres was the density of the air, the buffer-head would equilibrate a ing a force of about 68 tons. The total range given here to this 5½ feet; but it is obvious that any length of range desirable may be uch an instrument, so as to bring up a railway train with any required gentleness. From the properties of elastic bodies, the plunger when an imperfectly elastic system, such as a railway train, and driven in uld again rebound with considerable force, and would be liable to be lly out of the gland: this is provided for by a turned rod, marked *x*, the axis of the plunger, and passing through a small stuffing box in end of the outer cylinder, and having a large nut, and a number of llars to deaden the blow upon its extremity: this catches the plunger urn stroke. Such is the method I propose for bringing up a train at

allett next proceeds to describe another modification of his hydro-ic buffers to railways, for which we must refer the reader to vol. 422 of the Mechanic's Magazine.

rtis, who was some time manager of the Locomotive department of the railway, with the view to increase the safety of the carriages by the height of the centre of gravity, altered several carriages on that suspending the frame of each carriage below the axle, instead of it above the axle in the usual way.

Curtis's Passenger Carriage.—The carriage of which the following is a com drawing was built as a pattern carriage for the Boston and Providence U. railway in 1836: it is made upon the same principle as those of the London Greenwich railway company, viz.—It will be perceived upon reference to t



engraving, that it consists of five distinct compartments or coaches, the fi three immediately upon the top of the frame, and twelve inches only fro surface of the rail, so that passengers step in and out with as much faci from a sedan chair. The middle compartment has double seats, like coach, and the two end bodies single seats like a chariot; the two bodie the wheels have also single seats, and may be either close bodied or ope a leather curtain as drawn: passengers get in or alight by steps similar t of a barouche; the spaces over the low bodies may be employed for lu forming a commodious safe depôt for that purpose. If it should be desi form the mail coaches upon this principle, the space over the wheels formed into the holds, or receptacles for the mail bags; thus placing the h load over the wheels; also, if desirable, the roof may be adapted for passengers. Mr. Curtis observes that "it is evident from the constructio coach that it is absolutely safe, by no possible chance can it ever upset; not cost more than the railway carriages usually adopted, and by placing upon the cross pieces of the frame, descending so low as to clear the cr and setting them back from the wheels little more than the breadth of on each side, in the event of the wheels leaving the rail, the frame locks either the one rail or the other, and thus the carriage is retained to under all possible circumstances. This is a very valuable point, for wh recollected that almost every railway is formed for fully one third of it upon embankments without parapets, which renders it very dangerou engine or carriage to be thrown off the rails upon them, this arra provides a remedy for the case to be met by no other equally simple, ch efficacious means."

The carriages upon the Greenwich railway were altered by Mr. Cu the old and general plan of those upon the Liverpool, Birmingham a lines: this alteration was effected by simply inverting the frames.

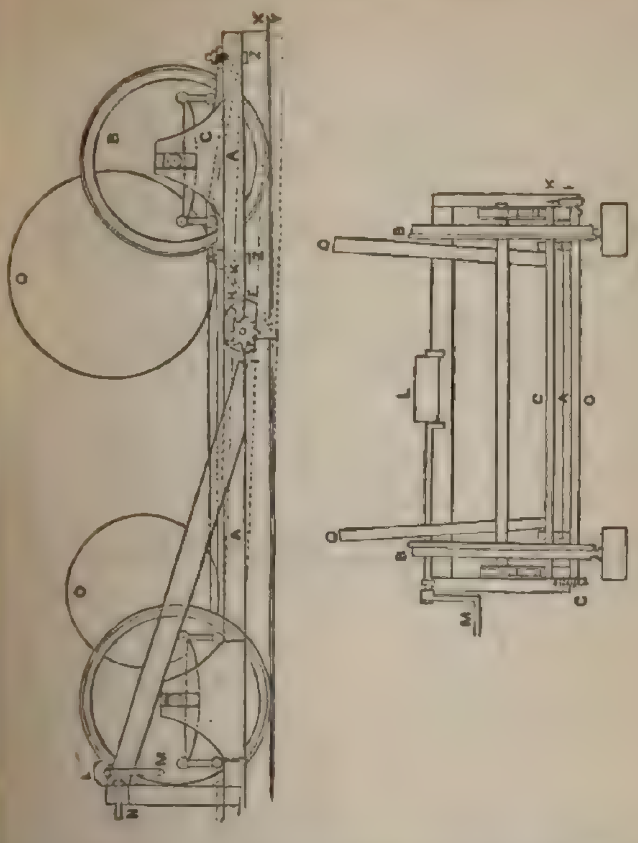
The following list of casualties upon the Greenwich line, which hap the low carriages, speak volumes in favour of the absolute safety of the c

"June 17, 1839, large open carriage with eight passengers, both axl was dragged upwards of a mile, without the least injury to passengers.

"Aug. 21.—Axle of carriage broke, two passengers in the coach; dragg the Croydon junction, and upwards of three quarters of a mile, witho to passengers.

"Sept. 15.—Break carriage axle broke, with eight passengers; dragge of a mile without injury to passengers.

"Upon two other occasions like accidents happened, with similar re in 1838, and the other in 1840."



Curtis's Railway Trucks.—Mr. Curtis has applied the principle of construction ... described to trucks for the conveyance of private carriages. *Fig.* 1 is a ... view, and *Fig.* 2 an end view, and *Fig.* 3 a plan of the machine: the same ...ters refer to the same parts of the machine in each *Fig.* so far as the parts ... shown in each. A is the framing of the machine, which is suspended below ... axle in the usual way; B the hind wheels connected with the shifting frame ...which frame is held in its place by the bolts D D D D, or by any other usual ...d suitable means; E E are two eccentrics hung upon the cross shaft F, upon ... end of which shaft the ratchet G is hung, and upon the other the head I, ...o the holes of which the lever K is inserted, when it is required to turn the ...ft F round, so as to bring the eccentrics into contact with the rails or other...e. L is a windlass placed upon the front bar of the machine, round which a ...e coils, so that when a carriage is required to be placed upon the machine, ... end of the rope is made fast to the carriage, and the other end to the wind...s, then a man turning the windlass round by means of the handle M, the ...riage is drawn upon the machine; the machine is connected to the train by ...ans of the coupling N in the usual way, and the diagonal bars are placed as ...wn, in order that the concussion of the train may be transferred to the main ...me of the machine A; O O O O are the wheels of the carriage placed upon the

machine: the body and carriage are omitted in the drawing, as it is not material to the explanation of the invention that they should be shown.

The mode of operation is as follows:—when a carriage is required to be placed upon the machine, the eccentrics are brought upon the rails, and made to occupy the position shown by the dotted lines in *Fig.* 1, the effect of which is to raise the end of the carriage to which the shifting frame and wheels are attached, a space equal to that included between the shaded line X and the dotted Y, and to support it whilst the frame C and wheels B are withdrawn; then the eccentrics are turned back until they occupy the position shown in the drawing, when the end of the machine is lowered to the ground, and occupies the position shown by the dotted lines Z Z. The carriage is then brought to the machine, the rope from the windlass is made fast to it, the floor of the machine being formed into an inclined plane; the carriage is dragged upon the machine by the windlass with great facility. When placed upon the machine the eccentrics are again brought into the position shown by the dotted lines, which raises the end of the machine; the shifting frame C and wheels B are connected with the machine, and made fast by the bolts D, the eccentrics are then brought into the position shown in the drawing, riding clear of the rails; the ratchet G and pall H are provided to retain the eccentrics in any position they may be placed in: the best way to effect all these operations, is to place the machine upon a turn-table, the fore wheels and eccentrics being upon the table, when the machine can be disengaged from the wheels, and placed to receive the carriage in a very simple and easy manner; the same operations apply if the machine is employed for goods, cattle, or any other purpose.

Railway Carriage Connectors.—The following engraving, *Fig.* 1, shows the mode in which railway carriages were at first attached together; which con-

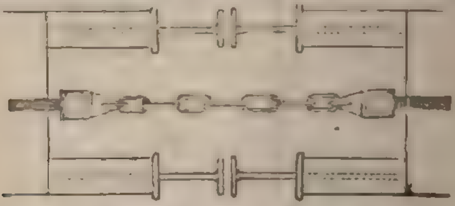


Fig. 1.

sisted simply of a chain, the buffers of one carriage not coming in contact with those of another, but each carriage was allowed, when moving onwards, a lateral oscillating motion.

In the subjoined engravings, *Figures* 2 and 3, Mr. Booth's highly improved method of connecting them is shown. It is a most complete invention for the purpose, and consequently adopted on almost every railway in the kingdom. *a* is the connecting chain attached to the draw-bar of each carriage, and consists of a double working screw (working within two long links or shackles, the sockets of which are spirally threaded to receive the screw bolts, which are fastened together by a pin and cotter, so that by turning the arm or lever Z of the said screws, the connecting apparatus is lengthened or shortened at pleasure, to the extent of the long links or shackles above alluded to, in which they work. This screw-chain being placed on the hooks, or turned-up ends of the carriage draw-bars *d*, the buffers *b* of each adjoining carriage being first brought close, or nearly close together, the lever Z is turned round a few times till the draw-bars *d* are drawn an inch or two beyond their shoulders, on the face of the carriage frame *c*, stretching the draw-springs, to which the draw-bars are attached, to the extent of a fourth or fifth part of their elasticity; and by this degree of force attaching the buffers of the adjoining carriages together, and giving by this means, Mr. Booth states, "to a train of carriages, a combined steadiness and smoothness of motion at rapid speeds, which they have not when the buffers of each carriage are separate from those of the adjoining

...w is a weight to keep the lever in a vertical position, and prevent ...screwing of the chain when in action.

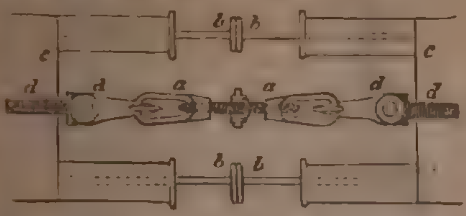


Fig. 2.

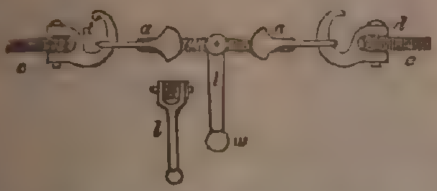
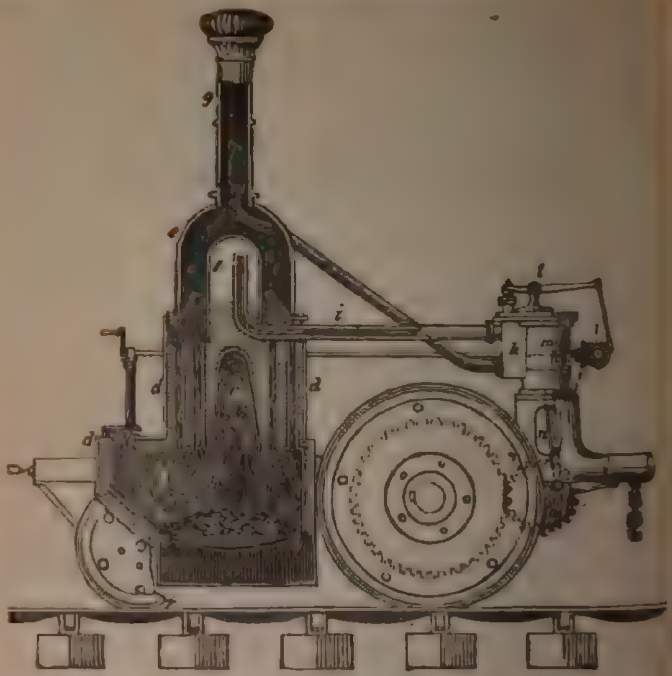


Fig. 3.

...king the speed, or stopping the Engine.—In the same patent as the ...ing apparatus just described, this very able and original minded inventor ...luded a novel method of checking the speed of the engine, or stopping ...ether. It is effected by introducing a throttle valve, slide, or damper, ...e blast pipe, which is usually placed in the chimney in front of the ... and which throttle valve may be most conveniently introduced where ... exhausting pipes are united into one, below the place where the pipe is ...ted in area for the purpose of producing a blast to the furnace. From ...rottle valve must proceed a rod or long handle extending through the ...y to the back part of the boiler, so as to lie within convenient reach of ...gine-man, who, by moving the said handle, can close the slide or throttle ...either partially, or altogether, as may be required. And the throttle ...eed not be altogether steam-tight, but should be made to work freely in .... The engine-man, when he wishes to stop or slacken the speed of the ... closes or contracts his throttle valve without shutting off the steam in ...age from the boiler to the engine. The pistons, by that means, are ..., but not suddenly or violently checked, and the driving wheels of the ... no longer revolving, or revolving very slowly, the engine is soon brought ...nd.

...'s Locomotive Engine.—The annexed cut represents a side elevation of ...markable engine; some of the parts, which could not well be explained ...e, are shown in section. It was patented by Mr. Benjamin Hick, of ... in October, 1834.

... is the ash-pit, *b* the fire-place, opening above into a dome *c* of the ... *d*, and surrounded by water; the external figure of the boiler is that of ...l cylinder; and as the dome *c* occupies the centre, the water chamber ...e most part of an annular form; this annulus has passing through it ...y numerous tubes open at each end, for the smoke and heated gases to ...n the furnace throughout the body of water, into the flue *e* above, and ...nto the chimney *g*. The draught through the furnace is increased by ...ing the induction steam pipe *k* from the engine into the throat of the ..., where a jet of steam is thrown upwards, in the way now commonly .... *f* is the steam chamber, enveloped in the heated gases that ascend ... furnace, which are made to impinge upon it with greater force by the ...tion of a plate of iron shaped like an inverted funnel; *i* is the steam ...hich conveys the steam from the chamber *f* into the valve boxes *k*,



worked by a series of levers at *l*, that are put in motion by bevel gear, an crank motion partly introduced. It is now to be clearly understood, that th are three steam cylinders *m*, but as they are all in a row, only one can be in our view; each of these cylinders is provided with suitable valves, working gear, to admit the steam *on the top only* of each of the pistons, at time of the descent of each, and to allow of its escape on their ascent. bottom of each of the cylinders is open, and the piston rods *n* are jointed the bottoms of the pistons, the latter being steadied in their motions by lateral rods passing through guide holes. The three piston rods act direc upon a three-throw crank, the equi-distant positions of which in the circle c the pistons to continue their reciprocating action, and the crank its rota motion, with uniformity. Fast and slow motions, and clutch boxes for vary the speed, are provided in the usual way. In our diagram is shown a pinio on the crank axis, driving a wheel on the axis of the running wheels.

The patentee especially claims under his patent the combination of two more cylinders, each having its lower end open, so that the steam shall p only upon the upper surfaces of the pistons, and communicate its power to crank shaft, or running wheels, in a downward direction only; which he siders will cause a greater adhesion between the wheels and the rail, and vibration to the carriage, than when the power is applied to the wheels i upward and downward, or a forward and backward direction, alternately.

The wheels applied to this locomotive also possess some novelty, and claimed under the patent right. They may be briefly described to consist cast-iron nave, duly formed and turned, to receive the edges of discs of p iron, in lieu of spokes; the felloes or external rings being fixed to the disc first expanding their circumference by heat, and allowing them afterward contract, so as to receive the edges of the discs in grooves turned to rec them. The several parts are afterwards secured by bolts, screws, rivets, keys, in a manner too well understood to need description.

tent Axle Grease.—Every circumstance relating to locomotion on railways ing become of importance, nothing escapes investigation, nor attempts at lioration. Amongst the many matters to which attention is necessary to le a locomotive machine to work well, is that of the lubricating substance. sagacity of Mr. Henry Booth, of Liverpool, has led him to effect an im- ment in this respect, for which he obtained a patent on the 14th of April, ; which he has denominated "The Patent Axle Grease, and Lubricating ." These, according to the specification, are chemical compounds of oil, , or other grease, and water, effected by means of the admixture of soda her alkaline substance, in such proportions that the compounds shall not a caustic or corrosive nature when applied to iron or steel, but of an ous greasy quality, easily fusible with heat, and suitable for greasing the bearings of carriage wheels, or the axles, spindles, and bearings of nery in general. The proportions of the ingredients, and mode of ounding them, are stated to be as follow:

"For the axletrees of carriage wheels, a solution of the common washing of the shops, in the proportion of half a pound of the salt to a gallon of water. To one gallon of this solution add three pounds of good clean and six pounds of palm oil; or, instead of the mixture of palm oil and , add ten pounds of palm oil, or eight pounds of firm tallow. The tallow palm oil, or either of them, and the solution as described, must be heated her in some convenient vessel to about 200° or 210° of Fahr. and then hole mass must be well stirred or mixed together, and continually agitated, the composition be cooled down to 60° or 70° of Fahr. and have obtained onsistency of butter, in which state it is ready for use."

e patent-lubricating fluid, for rubbing the parts of machinery in general, s made: to one gallon of the aforesaid solution of soda, in water, add of oil one gallon, and of tallow or palm oil one quarter of a pound. Heat together to about 210° of Fahr. and then let the fluid composition be well d about, and agitated without intermission until cooled down to 60° or 70°, it will be of the consistence of cream. If it be desired thicker, a little on of tallow or palm oil renders it so.

Historical sketch and principles of Atmospheric railways.—Papin.—Medhurst.—Pinku Vallance.—Pinkus's first patent Atmospheric railway.—Pinkus's second patent.—Cl Atmospheric railway.—Dalkey line.—Mallett's report on Dalkey line.—Conflicting the Atmospheric system of traction.—Vignoles.—Cubitt.—Brunel.—Mr. Stephenson Herepath's report.—Bergin's evidence.—Pilbrow's Atmospheric railway.—Keene a Pneumatic railway.—Hallette's Atmospheric railway.—Hallette's Pneumatic railway.— Conder's electro-magnetic railway.—Saxton's Differential Pulley.—Badnall's Undulatin Rope friction, Blackwall railway.—Farrill's Patent Archimedean railway.—Parker's railway.

THAT mode of propulsion which is effected by Pneumatic pre generally known as the Atmospheric system of railway; from the circ of the elastic medium which we breathe being, in most cases, the power. The practical introduction of this system is very recent, and perience on the subject is consequently very limited. But it has sanguine advocates and partisans; and is now, under variously modifi occupying the attention and study of different parties, who are devot talents and energies to perfect their several schemes, and bring t practical operation. We propose first to describe such of the plans been carried into effect, and afterwards notice those modification pneumatic principle of motion, which have been suggested as impr upon the original idea.

The idea of imparting motion to machinery at a distance from t mover by the intervention of air, is by no means of recent date. As as the close of the 17th century, Papin (for whom the French c invention of the steam engine) suggested the plan, and we believe both by the compression of air, and by its rarefaction, but complete Many years afterwards a trial of the plan was made upon a large scale but with no better result, and the plan seems to have fallen into oblivi in 1810, Mr. Medhurst of Denmark-street, Soho, published an acco " new method of conveying goods and letters by air," followed in 1 prospectus of a plan, by which he endeavoured to prove that goods and p might be cheaply and safely conveyed at a rate of 50 miles per hour. this, he proposed to construct an air tight tube of sufficient dimension a carriage to run within it, and having a pair of cast-iron wheel tracks laid along the bottom, for the carriage to run upon. The carriage w of nearly the form and dimensions of the tunnel, so as to prevent siderable quantity of air from passing by it; and the carriage w

of Mr. Medhurst. Mr. Vallance subsequently constructed a short tube in garden at Brighton, to demonstrate the practicability of the plan, and tion was occasionally made in the public prints of experimental trips which taken place; but the apparatus was not of sufficient extent to show forth the difficulties of the plan, or the extent to which they would be overcome; this scheme, like the previous one of Mr. Medhurst, was never carried into ct.

The most obvious objection to the plans we have just described, is the sity for the passengers to travel within the tube, excluded from daylight, this alone would have been sufficient to prevent their ever being acted upon. objection was first overcome by Mr. Pinkus, who by thus bringing the plan in the sphere of feasibility, may be considered as practically the inventor e Atmospheric railway. His plans, it is true, have not been adopted in all details as originally proposed by him, but, variously modified, they form the of the most promising schemes which have since been brought forward opelling by the pressure of the atmosphere. Mr. Pinkus's first plan, and hich he obtained a patent in 1834, is fully described in the first part of Encyclopedia, under the article "AIR;" it will be sufficient therefore in this to say that it consisted of a tube laid down between a pair of rails on h the carriages were to run, and having on the top of it a longitudinal e extending throughout its length. Within this tube was a piston, hed to the leading carriage of the train by an arm passing through the ve. This groove was closed by a thick cord, saturated with a composition x and tallow, in order to form an air-tight joint throughout the length of ube, except at the part where the piston arm projected through the slit, e it was raised out of the groove by rollers attached to the arm, so as to an opening for the admission of the air into the tube, at the back of the n. The tube in front of the piston was connected with an air pump, and tial vacuum being formed in the tube, the pressure of the atmosphere upon ack of the piston would propel it along the tube, and with it the carriages ected to it.

1836, Mr. Pinkus took out a patent, for his second plan of atmospheric lsion, which differs materially from his first, the travelling piston in the spheric main being dispensed with, and the system in some measure ilated to the locomotive system. The following is a description of the nearly as given in the Mechanic's Magazine:—A tube is laid down een two lines of rail, and communicates with air pumps placed along the which act upon the air in the tube, continually rarefying it as it is thrown y the working of the locomotive apparatus. The main has an opening upper surface, two inches wide; on to the edges of this opening are ed plates, forming what Mr. Pinkus calls a metallic valve, made of an am of iron and copper, hard rolled to make it elastic, 1-8th, of an inch thick lower edge, and 1-16th at the upper, (the insides of which are to be polished h,) and four inches high. The annexed cuts will show the thing more y. *Fig.* 1 is a plan of the valve, and *Fig.* 2 a cross section of the air main the valve attached, and the tongue (afterwards described) between the lips e valve. In both *Figs.* *a a* are the lips of the valve, which it will be seen, r undisturbed state, by their elasticity press upon one another, and form tight joint the whole length of the main. Working between the lips of ve, is a hollow metallic tongue (*b Fig.* 2), the shape of which is seen in 1. The sides of this tongue in contact with the lips of the valve are polish- d the tendency of the latter to collapse, by their spring pressing upon polished sides as they pass along, makes the joint air tight. This hollow e forms a communication through throttle valves, with a condenser or m vessel, and this vacuum vessel communicates, through alternating ges, (somewhat similar to those used in steam cylinders, and worked by centric from the crank,) with two cylinders in which work pistons, whose n cranks which give a rotary motion to the wheels of the locomotive. ode of action is as follows: the air in the main is kept rarefied by the ting engines at each end; a communication being made between it and

the rarefied air or vacuum vessel by opening the throttle valve, and between the vacuum and the cylinder by the sliding passage, a partial vacuum is formed under the piston, which the outward atmosphere forces down, giving half a turn to the crank; the alternating air passages are then reversed, the other piston is acted upon in the same way, and a revolution of the crank and consequently the carriage wheel is completed. The cylinder full of air, after having forced down the piston passes into the vacuum vessel, and through the hollow tongue into the main, from which it is pumped into the atmosphere by the stationary engines and air pumps at each end of the five mile section. As the tongue passes forward, it will open a passage for itself between the lips of the valve, which will immediately close behind it by the elasticity of the plates. The tongue is prevented from becoming hot by friction, by the current of cold air constantly passing through it from the cylinders.

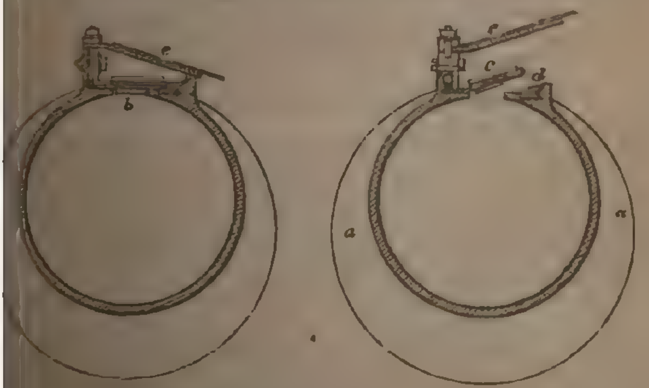
Although this scheme manifests considerable ingenuity on the part of the inventor, we think it upon the whole inferior to his first plan. In particular we would notice that the advance of the train depends upon the adhesion of the wheels of the propelling carriage to the rails, so that in unfavourable states of the rails, the wheels would be liable to slip, and also the power of ascending inclines would be diminished, as on the present system of traction by locomotive steam engines, whereas by the first plan, provided a sufficient pressure could be produced at the back of the piston to overcome the friction of the load and the power of gravitation, the train must advance whatever be the state of the rails, or the steepness of the incline.

Mr. Pinkus endeavoured to form a public company, to carry his invention into effect, but did not succeed in so doing. His efforts however had the effect of drawing public attention to the subject, and provoking discussion; and paved the way for Mr. Clegg, who in 1839 took out a patent in connexion with the subject, and eventually succeeded in procuring its adoption by a company, and who may therefore be considered in one sense as the introducer of the Atmospheric railway. The title which Mr. Clegg selected for his patent was chosen very skilfully, and, although it certainly may be said to cover the invention, could at that period scarcely be supposed to refer to railways, and was therefore little likely to meet with opposition from parties who were directing their attention to that subject. The title is for a new improvement in valves, and the combination of them with machinery; but it will be seen that the improvements do not refer to valves in general, but solely to a continuous valve for the purpose of Atmospheric railways; the following is an extract from the specification:—

"My improvements consist in a method of constructing and in combination with machinery. These valves work on a hinge other flexible material, which is practically air tight, similar commonly used in air pumps; the extremity or edge of these valv fall into a trough, containing a composition of bees'-wax and tallow and oil, or any substance or composition of substances which temperature of the atmosphere, and becomes fluid when heated

…d. After the valve is closed and its extremity is lying in the trough, …ow is heated sufficiently to seal up or cement together the fracture …the edge or edges of the valve, which the previous opening of the valve …sed, and then the heat being removed the tallow again becomes hard, …ms an air tight joint or cement between the extremity of the valve and …gh. When it is requisite to open the valve, it is done by lifting it out of …low, with or without the application of heat, and the before named …of sealing it or rendering it air tight is repeated every time it is closed. …mbination of valves with machinery is made in the application of these …o railways, or other purposes of obtaining a direct tractive force, to move …either on the railway or otherwise. This I effect by laying down a …ous length of pipe, containing a lateral slit or opening its whole length: …is made to travel in this pipe by exhausting or drawing out the air …e pipe on one side of the piston, and allowing free access to the …ere on the other side of it; an arm from this piston passes through the …opening, to attach to the carriages on the railway, and draws them along … The whole of this lateral opening is covered by the valve before …d, and that part of it through which the arm passes is lifted to allow it …and also for the admission of air to the piston by means of an apparatus …ed to the arm. The carriage to which this arm is attached we call the …carriage; to the hinder part of this carriage a long heater is attached, …drawn along by it upon the tallow contained in the trough, and reseals …e ready for the next train, which repeats the operation above described. …in distances, which are regulated by the nature of the road, steam …and air pumps or other apparatus are fixed, for exhausting the pipes, …a short distance beyond the connexion from the engine to the pipe …are placed, closing the end of one length or section of pipe and the …ng of the next, between which a space is left for stopping the trains if …d; these valves also divide the pipe into suitable lengths, to be exhausted …apparatus, or close to the end where it is not required to be continued, …clivities where the carriages will run by their own gravity; thus every …of pipe is enclosed at the two ends by these valves, and is exhausted by …steam-engine and apparatus. These valves, which I call the separating …are opened by the driving carriage, to allow the piston to pass, and are …after the train has passed."

… and 2 represent the construction of the valve, *Fig.* 1 showing a section …alve when closed, and *Fig.* 2 a section of the valve when open;



…section of the cast iron vacuum tube or atmospheric main, *b* is the …us valve of leather extending over the whole length of the opening on …r side of the tube, and strengthened by short plates of iron *e e*, attached

to the upper and under side of the leather, so as to impart firmne admitting a sufficient degree of flexibility. *d* is the composition by w edge of the valve is hermetically sealed. *e* is a protecting cover formed plates of iron about 5 feet long, hinged with leather for protecting t from rain, snow, &c; this cover however was, we believe, subseque pensed with when the invention was brought into actual operation.

An experimental line of railway was subsequently laid down at Wc Scrubbs, by Mr. Clegg and Mr. Samuda, who had an interest in th The length of the line was about half a mile long, with a rise of 1 in about half the way, and 1 in 115 for the remainder; the diameter atmospheric main was 9 inches, and the exhaustion was produced b of an air pump, of 37 inches in diameter, and 22 inches stroke, work condensing engine of 16 horse power. On this line several public exp were made, which were attended by many engineers, and other persons, some of whom formed a highly favourable opinion of the p the Dublin and Kingstown railway company were induced by the their engineer, Mr. Vignoles, to adopt it in the extension of their li the terminus at Kingstown to the village of Dalkey.

The length of this line is 3,050 yards, or nearly 1 mile and $\frac{3}{4}$, wit of $71\frac{1}{2}$ feet from the commencement at Kingstown to the termination at the average rise from the lowest point being 1 in 140, but the last 365 ya a rise of 1 in 57; there are also several sharp curves on the line, so th the whole it was well adapted to show the capabilities of the system f coming steep ascents, and sharp curves. The line is worked only one the atmospheric apparatus, the return being effected by the force of gr

As stated above, the length of the line is 3,050 yards, but the atm main is only 2,490 yards long, the remainder of the way, 560 yards, b by the momentum previously acquired. The diameter of the main is 1 and near its extremity branches out a pipe of the same diameter, whi to the exhausting apparatus, distant nearly 500 yards. The air pump, double acting, is $66\frac{1}{2}$ inches diameter, with a stroke of 66 inches. It is by a high pressure condensing engine, of $34\frac{1}{2}$ inches, and 66 inches working expansively, the cut off valve being regulated by a governor, vary with the speed of the engine, from $\frac{1}{2}$ at the slowest to $\frac{1}{4}$ at the c Mr. Samuda reckons this engine to be of 100 horse power, but it appe he assumes the horse power to be equal to 66,000lbs, raised one foot h minute; other engineers, calculating by Bolton and Watt's standard, that on an average it works up to 180 horse power.

At the entrance end, and some 30 feet from it, is a kind of balanc (corresponding to Pinkus's vertical sliding valve,) very ingeniously con open by the pressure of the compressed air in front of the piston; an other or exit end is another valve, opening outwards by means of t pression of the rarefied air, after the piston has passed the tube leadi the main to the air pump.

The continuous valve which covers the slit on the surface, is compo strip of oxhide of the best quality, strengthened above and below plates, and the leather is double in the part which closes the openin valve is fastened down by one edge, (as described in the extract from Mr specification,) and when down fits closely over the slit, its edge being by a composition of wax and tallow. From near the centre of the carriage descends an arm, which passes through the aperture of the the middle of the piston rod within the main. Before the point where is connected to the piston rod are two rollers, (the foremost of smaller than the other,) for the purpose of raising the valve, and be arm are two similar rollers, for the purpose of keeping open the valve part, and thus admitting the atmosphere to press on the back of the After the arm and wheels have passed, the valve drops by its own and is forced down close by a wheel at the end of the first carriage over it: a heater filled with red-hot charcoal was attached to a second for the purpose of melting the composition, but we believe has since b

unnecessary or ineffective. The advance of the train as it approaches on is retarded and finally arrested by means of a very powerful brake; kewise be arrested on any part of the line, without stopping the engine, s of a valve in the piston, connected to a lever attached to the leading by opening which valve the vacuum in front of the piston is destroyed, air before and behind the piston is in equilibrio.

y after the Dalkey line came into operation, the French government a Mons. Mallet to examine and report upon the operation of the system loped on that line. A translation of his report was subsequently d, from which we select the following extracts, showing the results by M. Mallet in his experiments.

he following experiments the velocity has been quoted with great care. division of the road, forming lengths of 44 yards (40m. 22.) as I have tated, the time has been marked by means of an instrument in the a watch, from which by touching a spring a drop of ink falls upon repared to receive it. This paper takes of course a regular rotatory From the time thus obtained the velocity is calculated. In my notes elocities of several trains calculated per hour, for each division, and to present their results in the most comprehensible form, I have them in quarters of miles, and in this manner formed the following

EXPERIMENTS ON THE WEIGHT AND VELOCITY OF TRAINS.

SPEED PER HOUR, EXPRESSED IN MILES, Corresponding to the					
First Quarter of a Mile.	Second Quarter of a Mile.	Third Quarter of a Mile.	Fourth Quarter of a Mile.	Fifth Quarter of a Mile.	Sixth Quarter of a Mile.
Miles.	Miles.	Miles.	Miles.	Miles.	Miles.
18 . 85	26 . 59	26 . 47	27 . 82	32 . 13	32 . 62
17 . 95	25 . 56	26 . 47	25 . 10	28 . 30	30 . 97
18 . 10	32 . 20	28 . 96	32 . 20	30 . 00	28 . 96
13 . 37	17 . 25	19 . 71	19 . 28	21 . 37	20 . 95
VELOCITIES AT THE DESCENT PRODUCED BY GRAVITY.					
13 . 69	20 . 27	22 . 24	20 . 56	21 . 20	21 . 00

table only comprehends six quarters of a mile, or 2413m. 50; the th of the line being 2787. 70, there remain 374 metres, the velocities are not reckoned in the table. These 374m. are at the terminus of

EXPERIMENTS ON THE WEIGHT AND SPEED OF TRAINS.

Weight of the Trains. English Weight.	SPEED PER HOUR, EXPRESSED IN MILES, Corresponding to the						
	First Quarter of a Mile.	Second Quarter of a Mile.	Third Quarter of a Mile.	Fourth Quarter of a Mile.	Fifth Quarter of a Mile.	Sixth Quarter of a Mile.	OBSERVATIONS.
Tons.	Miles.	Miles.	Miles.	Miles.	Miles.	Miles.	Weight of the Train. Tons.
60 . 40	12	20	22	21 . 5	21 . 5	21	7 Passenger Wagons...25 . 17 5 Wagons for Goods....27 . 10 Iron in Chains .... 5 . 03 47 Passengers .... 3 . 10 60 . 40
70 . 40	11 . 25	18	19	17 . 6	18 . 4	18	Wagons as above ....52 . 27 Iron in Chains ....10 . 03 121 Passengers .... 8 . 10 70 . 40
71 . 40	12 . 00	17	18	15 . 5	16 . 6	12 . 5	Wagons as above ......52 . 27 Iron ....10 . 03 134 Passengers .... 9 . 10 71 . 40

"These last experiments give us information on some points not previously noticed; viz. the height of the mercury in the barometer during the course of the train. For the first it stood at $24\frac{3}{4}$ inches at starting, and at $23\frac{1}{4}$ at the end of the journey: the second, after having sunk from $24\frac{3}{4}$ to $24\frac{1}{4}$ it rose to $24\frac{3}{4}°$: the third, it sunk from $24\frac{3}{4}°$ to 24 inches, and returned to its former level. In each of these experiments the resistance throughout the course was within a little on an equilibrium with the power.

Conflicting Opinions on the merits of the Atmospheric System.—The experience of the atmospheric system on the Dalkey line has called forth the most opposite opinions on its merits from engineers and other scientific characters; some asserting that the superiority of the atmospheric over the locomotive system is clearly established by the results obtained, whilst others maintain that these results prove not merely that it is inferior to the locomotive system, but that it is utterly inapplicable in the generality of situations and circumstances in which railways are called for. Amongst those who have formed a favourable opinion of the scheme, we may mention Mr. Vignoles, the engineer to the Dublin and Kingstown railway, at whose recommendation the trial of the system on the Dalkey line was made, and who has since decided upon adopting it on a line from Vienna to Schonbrunn. This line, however, is to be a double line, thereby obviating some of the objections raised against the system on the score of the difficulty of working the lines with regularity and punctuality—but at the same time annulling most of the advantages claimed for the system in point of economy of construction and of working. Mr. Brunel has not only expressed a decidedly favourable opinion of the system, but has adopted it on a line now constructing by him (the South Devon, if we recollect rightly). Mr. Cubitt, although expressing a more qualified opinion, has deemed the plan worthy of trial on a portion of the Croydon line, in contemplation of its

...tion on the line from Croydon to Epsom; and an atmospheric ...ss from the latter place to Portsmouth. The French Govern-...quence we believe of M. Mallet's report) have likewise shown ...tain a favourable opinion of the plan, by ordering it to be applied ...from Arras.

...e side of the question are ranged amongst others the names of ...son, Mr. Bidder, Mr. Nicholson, and Mr. Herapath.

...Report.—Mr. R. Stephenson, in a most able and impartial report ...heric railway, addressed to the directors of the Chester and ...ay, comes to conclusions extremely unfavourable to the invention. ...s views are founded entirely upon experiments made by himself ...ts; which are so fully and clearly detailed in the report, and ...clearly but temperately stated, that we regret that our limits ...of our giving more than a summary of this valuable document. ...ject treated of in the report is the amount of leakage. To deter-...unt for each part of the apparatus separately when at rest, the ...pped after a certain amount of exhaustion had been effected, and ...h the mercury in the barometer fell was noted, repeating the ...various lengths of the vacuum tube, and with the pump and ...pe alone. These experiments show that the amount of ...nute may be taken as uniform, and the average of a considerable ...n gives the leakage, at the density of the external air, as 219 ...inute for the connecting pipe and air pump, and 252 feet per ...vacuum tube, or 186 cubic feet per minute for a mile in length. ...e goes on to observe,—"but it is evident that all leakage must ...to the vacuum tube, not at the density of the external atmo-...anded according to the degree of rarefaction of the air in the ...e the effect of this constant amount of leakage upon the velocity ...the vacuum tube will be various at the different heights of the ...r example, at Kingstown the leakage of the connecting pipe and ...bic feet per minute, and that of the vacuum tube 252 cubic ..., or, 471 cubit feet of air at the density of the atmosphere is ...e the vacuum tube in each minute. but if the height of the ...e tube be 15 inches, or the air twice rarefied, the effect of this ...doubled, and the quantity of air to be extracted from the tube in ...ll be increased by 942 cubic feet; and if the air in the tube be five ...or the barometer stand at 24 inches, it will be increased by 2,355 ...ad of 471 cubic feet, in each case. As the degree of exhaustion ...etarding influence of the leakage upon the speed becomes more ...ts; for while the velocity of the air pump piston remains con-...early so, and the cubic extent of each stroke is the same what-...ty of air, the effect of the leakage is increased with the ...l the maximum velocity attainable by the train is proportionably

...calculating the effect of these conditions upon the velocity, the ...in a table of great extent, the experiments made to ascertain the ...ties under different circumstances. We have arranged Mr. ...ummary of the results in Table A.

...nson then proceeds to calculate the effect of the leakage ...with the apparatus in a state of rest) upon the theoretic velocity, ...the velocity of the air pump piston, and the ratio between its ...ea of the piston in the vacuum tube, and the calculation shows ...theoretic velocity of from 7 to 30 per cent. in the apparatus ...and from 12 to 48 per cent. with a vacuum tube of 4 miles in ...varying as the pressure is increased from 3 to 12·2 lbs per inch. ...ble difference is also found between the practical velocity and ...ed, showing a further loss of velocity, increasing from 26 to 41 ...en the pressures of 9 and 12·2 lbs per inch, making a total loss ...al velocity between these pressures varying from 39 to 71 per cent.

TABLE A.

No. of Train.	Weight of Train.	Vacuum at Starting.	Highest Vacuum.	Highest Velocity.
	Tons.	Inches.	Inches.	Miles per hour.
1	23 . 2	8 . 3	13 . 7	30 . 0
2	24 . 7	8 . 0	16 . 7	35 . 0
3	25 . 0	9 . 7	17 . 5	35 . 0
4	26 . 5	8 . 7	18 . 5	34 . 7
5	30 . 8	8 . 5	19 . 0	32 . 0
6	31 . 3	11 . 5	19 . 1	32 . 1
*7	34 . 7	18 . 0	20 . 0	29 . 0
8	36 . 8	10 . 7	20 . 7	28 . 3
†9	38 . 3	5 . 2	21 . 0	28 . 3
10	42 . 5	8 . 6	22 . 1	25 . 7

* This high vacuum at starting was obtained by holding on the brakes.
† This Train started with this vacuum owing to a portion of the train standing on the downward incline.
The weight of the ten following trains increased gradually to 64.7 tons, and the height of the barometer to 24.4 inches.

This difference between the calculated velocity and that obtained in practice sho that the amount of leakage is greater when the apparatus is in motion; part which Mr. Stephenson supposes to arise at the air pump and at the tube pist

Upon the subject of the weight drawn, friction, maximum velocity, &c., t author gives the following table, (B.)

In this table those trains are selected from the twenty experiments befo mentioned which present the most uniform and valuable results: the data f calculation are given in the first 7 columns; the 8th column gives the tot power of the air pump during the whole time the engine was in motion. In ea experiment the mean resistance to the air pump piston is multiplied into t velocity of the air pump piston, and is increased in the proportion between t total time the air piston was in motion, and the time required for a train ov the entire distance, at its maximum uniform velocity. The power indicated l the air pump during the motion of the train, as shown in the 9th column, is fou by multiplying the total resistance to the air pump piston due to the maximu uniform vacuum into the velocity of the piston, and subtracting the produ from the total power of working the air pump (column 8), the remainder sho the power absorbed in attaining the vacuum, as given in column 10. Colum 11 gives the amount of power absorbed by the train at its maximum unifor velocity on the ascent of 1 in 115; and column 13 gives the power indicat by the friction and gravity of the train, multiplied into the maximum unifor velocity. It will be observed that this power is in every case less than th indicated by the maximum velocity of the train; and the difference betwe the two, enormous as it is at the higher velocities, Mr. Stephenson conside must be ascribed to the resistance of the atmosphere; and it is accordingly plac under that head in column 14.

In connexion with this part of the subject Mr. Stephenson observes, " referring to this column representing the loss of power from the resistance the atmosphere, it will be observed there is a very rapid reduction in the lo as the speed is diminished; indicating most satisfactorily the excessive expen ture of power, and consequent augmentation of expense, in working at hi velocities upon railways." This remark is of course equally applicable to railways, whatever may be the motive power employed, and it is here introduc only for the purpose of showing, that the attainment of speed exceeding th which is now reached upon some of the existing lines of railway, is a matter extreme difficulty, and that the atmospheric system is not exempt from th

TABLE B.—LOSS OF POWER WITH DIFFERENT WEIGHTS OF TRAIN.

No. of Train.	TRAIN. Weight.	TRAIN. Friction and Gravity.	TRAIN. Maximum uniform velocity.	VACUUM TUBE. Height of Barometer.	VACUUM TUBE. Pressure of Vacuum.	VACUUM TUBE. Area.	Total power of working Air-pump.	Power indicated by Air-pump during Motion of Train.	Power absorbed in attaining the Vacuum.		Power indicated by maximum uniform Velocity of Train.	Loss of Power indicated by maximum uniform Velocity of Train.		Power indicated by Friction and Gravity of Train.	Loss by resistance of atmosphere, and friction of Piston-valve.	
No.	Tons.	lbs.	Miles per hour.	Inches.	lbs per square inch.	Square Inches.	Horse-power.	Horse-power.	Horse-power.	Per Centage of Total.	Horse-power.	Horse-power.	Per Centage of Total.	Horse-power.	Horse-power.	Per Centage of Total.
4	26.5	781	34.7	18.5	9.2	176.7	322	176	146	45	150	172	53	72	78	24
5	30.8	907	32.0	19.0	9.5	176.7	336	181	155	46	143	193	57	77	66	20
7	34.7	1023	29.0	20.0	10.0	176.7	454	184	270	59	137	317	69	79	58	13
8	36.8	1084	28.3	20.7	10.4	176.7	350	186	164	47	139	211	60	82	57	16
9	38.8	1120	28.8	21.0	10.5	176.7	381	186	195	51	140	241	63	85	55	14
10	42.5	1253	25.7	22.1	11.0	176.7	389	184	205	53	133	256	66	86	47	12
11	43.8	1292	25.8	22.5	11.2	176.7	386	181	205	53	133	253	65	87	46	12
12	45.5	1341	25.2	22.7	11.3	176.7	427	181	246	58	134	293	69	90	44	10
14	51.0	1503	22.7	23.9	11.6	176.7	396	173	223	56	124	272	68	91	33	9
15	53.5	1576	21.7	24.0	12.0	176.7	460	170	290	63	123	337	73	91	32	7
17	58.0	1709	20.4	23.8	11.9	176.7	506	170	336	66	114	392	77	93	21	4
18	59.8	1763	18.0	23.6	11.8	176.7	390	170	220	56	100	290	74	85	15	4
20	64.7	1707	16.7	24.4	12.2	176.7	415	162	253	61	96	319	77	85	11	3
NO. OF COLUMN.																
1	2	3	4	5	6	7	8	9	10		11	12		13	14	

wasteful application of power which high velocities inevitably en ail. We h in the experiment No. 4, the effective application of a power of 150 horse, which 78 horse power, or upwards of 50 per cent., is absorbed by the resista of the atmosphere at a velocity of about 35 miles per hour.

We would call the reader's attention to the power absorbed in obtainin vacuum, as ascertained by a comparison of column 8 with column 9, and forth in column 10. Mr. Stephenson observes, "It may not be at first cle understood why the power of this column (8) exceeds so greatly that give the next (9), which is the actual power required to work the air pump; but will be apparent when it is remembered, that the positive power has l here increased in the proportion of the total time the air pump was at wor the time required for the train to pass over the entire distance at its maxi velocity, which increase has been made in order that a direct comparison be instituted between this total power and the power required for each of various resistances of the train." We think this point has not been suffici kept in view when the power required in the atmospheric railway has bee question, and that, if not a fatal, it is at least a formidable objection t atmospheric system under any arrangement, and that it goes far to neut one advantage claimed for the system,—that the dead weight of the engin tender is got rid of. To illustrate this, let it be supposed that the vacuum i main is produced, not by a pump worked by a stationary engine, but travelling piston in the tube, connected to a locomotive engine, the train connected to another piston detached from the former; and that the tance between the pistons at starting is equal to the length of a se of the tube—say 2 miles: then, if the resistance of the train be eq lent to a pressure of 15 inches of mercury on the area of the pisto in other words, if the air in the tube be rarefied to half the density c atmospheric, it is clear that the locomotive piston must travel two miles b the train begins to move; and if we suppose the engine to be provided means of cutting off the steam, so as always to proportion it exactly t resistance, still the power employed in producing the vacuum requisite to s train in motion will be nearly that required to propel the train half the l of the section, or to propel half the load of the train the whole length c section. If the resistance of the train required the air in the tube to be ra to one fourth of the density of the atmosphere, equal to a pressure of 22½ i of mercury, the locomotive would have to travel over six miles ere the train begin to move, and the power thus expended would be equal to that req for propelling the entire train three-fourths of the length of the section, propelling three-fourths of the train the entire length of the section: in words, the effect is the same as if an addition had been made to the dead wei the train, equal in the first supposed case to half, and in the second to t fourths of the weight of the train. Now, by referring to the table it will b that the 18th train, weighing 59·8 tons, required a vacuum in the tube to 23·6 inches of mercury; the power lost, therefore, in this case, w equivalent to an addition of a dead weight to the train of more than three-fo of the whole weight, or more than 45 tons. But the weight of the largest e with its tender on the Great Western railway we believe does not excee tons, and it is stated that one of these engines would take 156 tons of load at 45 miles per hour; in this instance, therefore, the dead weight c locomotive is only about five-ninths of that of the atmospheric, and const only one-sixth of the gross load; whereas, on the atmospheric line, it is eq three-sevenths of the gross load. In the above calculation no account has taken of leakage, which would of course increase the amount of power los

Having given the results obtained on the Dalkey line, Mr. Steph proceeds to draw a comparison between the working of the Atmospheri the other systems. As an example of fixed engines with ropes, he selec incline on the Birmingham line, between Camden Town and Euston S because it presents a case which is similar to that at Kingstown; or, at all e the disparities are not such as will materially interfere with the compa The following table exhibits the results of experiments upon this incline,

calculations founded thereon; observing that the friction of the several trains taken (as on the Dalkey line) at 10 lbs per ton, added to the gravity due to the average gradient.

TABLE OF EXPERIMENTS AT THE CAMDEN TOWN STATION.

TRAIN.			POWER ABSORBED BY						
Weight	Friction.	Gravity	Friction and Gravity of Rope.	Friction and Gravity of Train.	Resistance of Atmosphere		Train, excluding Engine and Rope.	Total, excluding Engine.	Power lost by Rope.
Tons	lbs.	lbs.	lbs per Ton of Train	Horse-power.	Horse-power	lbs per Ton. of Train.	Horse-power.	Horse-power.	Per Centage of Total
35	350	740	24 . 1	58	13	7 . 0	71	116	39
40	400	815	21 . 1	67	15	7 . 0	82	127	36
45	450	951	18 . 7	75	17	7 . 0	92	137	33
50	500	1057	16 . 8	[illegible]	19	7 . 0	102	147	30
70	700	1479	12 . 0	116	24	6 . 5	140	185	25
90	900	1902	9 . 3	149	29	6 . 0	178	223	20
110	1100	2324	7 . 7	188	32	5 . 5	215	260	17

Constants.—Average gradient 1 in 106: length worked by rope ·91 miles; ght of rope 7 tons; area of both cylinders 2904 square inches; velocity of ons 224 feet per minute; mean pressure on piston 2 ·9 lbs and 3 ·0 lbs per re inch, friction of engine 13 H. P.; friction and gravity of rope 45 H. P.; city of train 20 miles per hour; friction and gravity of train 31 ·1 lbs per of train.

r. Stephenson then compares the fourth train in the last table with the teenth train in the preceding table, being two cases which present the est analogy in the amount of their resistances and velocity. The loss of er from working the rope, as shown in the table, is 30 per cent of the whole; this must be increased in the proportion of the mean to the maximum city, which in this instance is ascertained, from experiments made, to add ty-seven horse power to the loss, making the total loss by the rope on the on incline 45 per cent. whilst on the Dalkey line the loss by the atmospheric ratus is 74 per cent. This result is obtained with what may be regarded n average train on the Euston incline; it is evident therefore that in this icular instance the rope is considerably more economical than the Atmospheric em. Assuming other weights of train, as the weight of the train is nished the proportionate loss by the atmospheric decreases, and the loss the rope augments; whilst by increasing the weight of the trains the ortionate loss by the atmospheric is augmented, and that by the rope minished. Comparing the atmospheric with the locomotive system, Mr. henson admits, with light trains upon steep inclines and at considerable tics, the atmospheric system (in common with all systems in which onary engines are employed) may possibly exceed the capabilities of motive engines; but that if the loads be converted into equivalent loads on el, then the locomotives have the advantage. Thus, taking the experiment in the table of the Dalkey performances, (which he considers as indis-

putably the most favourable one recorded,) the load was 26·5 tons taken up an incline of 1 in 115 at a speed of 34·7 miles per hour, which he shows to be equivalent to 44 tons upon a level at the same speed of 34·7 miles per hour; but this is much exceeded daily on many lines of railway, and especially by the Great Western, and the Northern and Eastern. On a long series of steep gradients, extending over several miles, and where the nature of the traffic is such that it is essential to avoid intermediate stoppages, the atmospheric system would be most expedient; but if intermediate stoppages are not objectionable, as in the case of the conveyance of heavy goods and mineral trains on the railways in the neighbourhood of Newcastle-upon-Tyne, the application of the rope is preferable to the atmospheric system, as is fully established by the comparison made between the Kingstown and the Euston inclines.

On the questions of expense of construction, and of working a long line of railway, the report is equally unfavourable to the atmospheric system; but upon these points the arguments are necessarily based upon assumptions, as, from the fact of the system not having yet been brought into operation on an extended scale, no reference can be made to experience; and the premises upon which Mr. Stephenson argues are so widely different from those assumed by the advocates of the atmospheric system, that we cannot be surprised at the enormous discrepancy of the conclusions at which they severally arrive.

In computing the cost of construction under the atmospheric system, its supporters always assume that a single line will be sufficient; but this Mr. Stephenson does not admit; on the contrary, he contends that the only means by which the atmospheric system can (if at all) meet the various exigencies of ordinary railway traffic, is to employ a double line of tube: this at once doubles the actual cost of the apparatus, and at the same time disallows those claims to economy of construction, founded upon the smaller quantity of land required, and the diminished size of the bridges and tunnels. We regret that our space will not allow us to give at length the arguments by which Mr. Stephenson supports his opinions, and that we must limit ourselves to his calculations of the comparative cost of the system.

Mr. Samuda, modifying his calculations by his experience on the Dalkey line, gives the following as his estimate of the cost for the apparatus, as applicable to such lines of railway as the London and Birmingham:—

COST PER MILE IN LENGTH.

Vacuum tube 15 inches diameter	£1,632	
Longitudinal valve, &c.	770	
Composition for lining, and valve groove	250	
Planing, drilling, &c.	295	
Laying, joining, &c.	295	
Station valves, and piston apparatus	100	
		£3,312
Engine, 100 horse power, with pump, &c.	£4,250	
Engine house, chimney, &c.	450	
Total for $3\frac{1}{2}$ miles	4,700	
Cost per mile in length		1,343
Total cost per mile		£4,685

On this Mr. Stephenson remarks, "It will be observed, that Mr. Samuda has only estimated for a single line of vacuum tube, and a single series, under the impression that such an arrangement is adequate to meet every necessity; but from what has been said on this part of the subject, I think it is made evident that such a limitation in the arrangements on any important line of communication would be very inexpedient, to say the least: I have consequently revised this estimate, and the following appears to me to be the minimum

expense at which the atmospheric apparatus could be applied to any extensive line of railway :—

COST PER MILE IN LENGTH.

Vacuum tube 15 inches diameter		£7,000
Two engines, 250 horse power each, at 33,000 lbs, with pumps, &c. complete, at £25 per horse power	12,500	
Engine house, chimney, reservoir or well	1,500	
Total for 3½ miles	14,000	
Cost per mile in length		4,000
Total cost per mile . . .		£11,000

"This amount exceeds Mr. Samuda's estimate very considerably, but the cause has been sufficiently explained.

"The power of the engines that I have assumed may at first appear large, but taking the engine on the Kingstown and Dalkey railway as our guide, it will be found, that the power reckoned upon does not exceed that which would be required to ensure sufficiently high velocities, with only the average passenger trains which now travel on the London and Birmingham railway; and we must bear in mind that the atmospheric system involves the necessity of employing very nearly the same power with light as with heavy trains.

"The engine at Kingstown may be taken at nearly 200 horse power, and capable of moving a train of about 36 tons, upon a gradient of 16 feet per mile, at 35 miles per hour. If we extend the length of tube to 3½ miles, when the increased leakage is added, the power required to move even such a load (which is below the average load of the London and Birmingham traffic) at this velocity, will be upwards of the 250 horse power, which I have assumed as requisite, and which makes the gross expense £11,000 per mile. *

"By referring to the half yearly statements of accounts of the London and Birmingham railway company, it will be seen that the capital invested in locomotive engines up to 31st December, 1843, was £171,974 17*s.* 6*d.* For the purpose of arriving at the whole capital actually invested under the head of power, we must add locomotive engine stations for repairing &c.: this item is not separately stated in the account, but we shall be safe in taking it at £150,000, making the total investment for power, £321,974. It must be understood that I am not attempting here to comprise all the sums which might come under this heading, supposing the accounts to be fully dissected, my only object is to make a comparative estimate, which is done correctly enough without introducing such items as would be common to both systems. The comparison of capital expenditure for power upon this basis on the London and Birmingham railway, would stand thus:—

Locomotive engines and stations	£321,974
Atmospheric apparatus for 111 miles, at £11,000 per mile	1,221,000

making a difference in favour of the locomotive system, as far as capital in power is concerned, of £899,026. This large disparity in the cost of the two descriptions of power might, it is urged, be more than saved by a reduction in the original cost of construction of the railway. This is partially true in the case of the London and Birmingham railway, but not by any means to the extent generally imagined.

"I cannot now attempt to enter into the minutiæ of this part of the subject, because it would involve a complete revision of all the original plans, and numerous considerations which could not now be fairly weighed. For the purpose, however, of carrying out the comparison regarding capital in this

* Mr. Stephenson takes 33,000lbs as the standard of horse power, but Mr. Samuda takes [illegible]. Therefore, the engine which Mr. Samuda reckons at 100 horse power, Mr. Stephenson [illegible] as [illegible] horse power, so that the actual difference in the estimate of the power required [illegible] the pipe is only as 100 to 125.

particular case, we may suppose that a saving of £900,000 might have b accomplished in the original design, by the application of the atmosph system, still, it would only have been a transfer of expenditure from exca tions, tunnels, and bridges, to steam engines and pipes; the ultimate cap would thus have been the same.

"If we now take some other lines of railway, with the view of ascertai how far their cost could have been diminished by the application of atmospheric system, we shall find that as the surface of the country beco more favourable, the economy in construction entirely disappears, and w we arrive at a perfectly plain country, such as exists in the eastern countie England, where few provisions are required in the form of excavati tunnels, and bridges, the application of the atmospheric system wo certainly double the original cost where a double line of rails is emplo The Grand Junction railway is a case where no reduction of original co could have been effected, since the gradients already conform to the nat surface of the country throughout a very large proportion of the whole l The adoption of the atmospheric system in this case would therefore h caused a very large augmentation in the capital of the Company, probabl much as £8,000 per mile, being the difference of cost between the two desc tions of power."

Mr. Stephenson next proceeds to give an approximate statement of the of working the two systems, excluding such items as are common to both; he observes, that "while the cost of the locomotive power is taken from accounts of the company,—the principal items, and only those, which may taken as certain in the cost of the atmospheric system, are taken into account in the comparative statement; in the latter, many minor expe in the absence of experience must unavoidably be omitted; thus giving a advantage in the comparison to the atmospheric system."

"The expense of locomotive power upon the London and Birmingh railway for the year 1843, was as follows:—

Wages of engine drivers and firemen	£9,673
Coke	25,541
Oil, hose, pipes, and fire tools, pumping engines and water	4,099
Labourers and cleaners, waste and oil	4,194
Repairs of engines and tenders	12,521
Coals and fire-wood, expenses of stationary engine at Wolverton, repairs of buildings, gas, and incidental charges	3,172
Superintendent, clerks, and foremen's salaries, and office charges	4,634
	£63,834

"The expense of working the atmospheric system for one year, I esti approximately as follows:—

Wages of engine men	64 at 6s.	£10,512
,, stokers	64 at 3s.	
The same during the night		10,512
Coal, 172 tons per day, at 9s.		28,332
Oil, hemp, tallow, and repairs at 5 per cent. on cost of engines		20,000
Superintendence, same as locomotive		4,634
Annual cost		£73,990

This statement, in Mr. Stephenson's opinion, sufficiently establishes the that the cost of working the London and Birmingham railway, or any o line with a similar traffic, by the atmospheric system, would greatly exc that by locomotive engines.

aving concluded his observations upon the question of power, original y, and cost of working, the two latter having reference chiefly to the don and Birmingham railway, he proceeds: "I will now offer one brief rk on the application of the atmospheric system to lines where the traffic very moderate extent. The London and Birmingham railway having an ralleled traffic, it is one of the best cases, in a general point of view, to h the atmospheric system could be applied. Let us now conceive it ed to a case of an opposite character—for example, the Norwich and outh railway, which has cost about £10,000 per mile, including stock and y appurtenance. This line passes over a country in which the application of mospheric system could have effected no economy whatever in the formation e line, which has not exceeded a cost of £8,000 per mile. The applica- of a single line of the atmospheric apparatus would, in this instance, added at least £5,000 per mile, which upon 20 miles, the length of the y, would amount to £100,000. The mere interest of this sum, at cent., is £5,000 per annum; whereas, the actual working of this line, ding maintenance of way, booking offices, porterage, and all other nt traffic charges, has been let for £7,000 per annum; being only £2,000 the bare interest of the extra capital which would be required to lay the atmospheric apparatus, an amount which would be quite inadequate et the wear and tear of the machinery alone, leaving nothing to meet the nt cost of working. Here, therefore, we have a case where the country is rable, the original capital small, and the traffic moderate, where the cost atmospheric system would be so burthensome as to render it totally plicable."

r Stephenson sums up in the following manner:—

. That the atmospheric system is not an economical mode of transmitting r, and is inferior in this respect both to locomotive engines and stationary es with ropes.

. That it is not calculated practically to acquire and maintain higher ities than are comprised in the present working of locomotive engines.

. That it would not, in the majority of instances, produce economy in the nal construction of railways, and in many would most materially augment r cost.

h. That on some short railways, where the traffic is large, admitting of s of moderate weight, but requiring high velocities and frequent departures, where the face of the country is such as to preclude the use of gradients ble for locomotive engines, the atmospheric system would prove the most ble.

h. That on short lines of railway, say four or five miles in length, in the ity of large towns, where frequent and rapid communication is required een the termini alone, the atmospheric system might be advantageously ied.

. That on short lines, such as the Blackwall railway, where the traffic is y derived from intermediate points, requiring frequent stoppages between termini, the atmospheric system is inapplicable, being much inferior to the of disconnecting the carriage from a rope, for the accommodation of the mediate traffic.

h. That on long lines of railway, the requisites of a large traffic cannot be ed by so inflexible a system as the atmospheric, in which the efficient ation of the whole depends so completely upon the perfect performance of individual section of the machinery.

rapath's Report.—Mr. Herapath published a most able and searching ysis of M. Mallet's report; but, from the great length we have already ted to this part of the subject, we can do little more than notice his vations upon the amount of power expended in relation to the mechanical s obtained.

e observes that "the relative areas of the air pump, and of the tube, and umber of strokes made by the air pump per minute, being known, we

obtain the length of main that could be exhausted in an hour, which is the rate the load should travel per hour, if there were no loss from leakage. Again, having the exhaustion of the main in inches of the barometer, and the sectional area of the main, we get the tractive power, supposing there was no friction in the main. This tractive power multiplied by the velocity, gives the dynamic effect (or momentum) which the atmospheric railway should have, if there was no leakage or friction of the piston with its gear: hence, comparing this with experiment, we get the waste of power employed, or the expenditure to produce a given effect, independently of knowing the power of the engine.

"We have shown that the air cylinder would extract 73.154 yards of the main at every stroke, consequently, there being 22 strokes a minute, we have

$$\frac{73.154 \times 22 \times 60}{1760} = 54.865 \text{ miles per hour}$$

for the velocity of a train, if there was no leakage at all. Either up hill, or on a level, this velocity should be the same if the apparatus was perfect. Moreover, the sectional area of the main being 176.71 inches, and the pressure of a column of mercury one inch high being 49lbs., we shall have for the pressure of an exhaustion of 24.75 inches—that at which the last experiment (p. 492) was made,—$176.71 \times 49 \times 24.75 = 2143.1$lbs. But a ton of goods going up an incline of .00719, gravitates backwards 16.10lbs, and if the road friction of the carriages is 8lbs. per ton, we have 24. 1lb. for the tractive force to draw one ton up an incline of .00719. Therefore $\frac{2143 . 1}{24 . 1} = 88.923$ tons. Hence, the atmospheric should take 88 . 923 tons up the Dalkey incline, at the rate of 54 . 865 miles per hour, but it only takes 71 . 4 tons at a speed of 15 . 92 miles an hour. Therefore, what the apparatus does do, is to what it should do, as $71 . 4 \times 15 . 92 : 88 . 923 \times 54 . 865 :: 1 : 4 . 3$. That is, between friction and leakage, the useful effect is not a fourth of what it ought to be, and this, it will be observed, is on the maximum effect of the plan."

On the subject of the cost of working the line, taking Mr. Bergin's statement, that the expense amounts to £1,171 per annum for the whole line, he observes, that this is equal to £781 per mile, and gives the following comparative view of the cost of motive power on the atmospheric and the locomotive systems.

Great Western locomotive	£357
London and Birmingham ditto	575
Dalkey Atmospheric	781

Again, comparing the working expenses at Dalkey with those of the Camden station, where fixed engines and ropes are employed, he computes the cost of fuel and wages at Dalkey by the same scale as these items are charged at the Camden station, and he makes the cost of the Dalkey line to be £1,950, £1,300 per mile. By the statement of Mr. Creed, the secretary to the London and Birmingham line, it appears that the expenses of the Camden station for the year 1843, amounted to £1,441, and the line being 1 mile 4 chains in length, this is equal to £1,372 per mile.

Bergin's Evidence.—Mr. Bergin, the superintendent of the Dalkey line, in his evidence before the Committee of the House of Commons, on the Portsmouth atmospheric line, stated that the average consumption of coal was 37 cwt. per day, and that the expense of working the line was £1,171 per annum, which he distributes as follows:

Coals, engine house and men	£900
Piston, continuous valve, and men to attend the same . .	271
	£1,171

which is equal to £670 per mile per annum. The cost of haulage he calculates to be 10*d*. per train per mile.

Pilbrow's Atmospheric Railway.—Although, as we have shown, the results obtained on the Dalkey line are not universally regarded as in favour of the

-ospheric principle, many eminent engineers contending that they decidedly -blish its inferiority to the locomotive system, it is clear, from the many -ntions which have since been brought forward in connexion with the -ject, that the principle of atmospheric, or at least pneumatic propulsion has -rvent partisans, who consider that all that is required to establish its -riority is either new modes of applying the principle, or improvements in details of execution. From the interest excited by the subject we shall -ceed to notice a few of these inventions. We shall commence with Mr. -brow's atmospheric railway, the distinguishing characteristic of which is, that -atmospheric main or tube is closed throughout its length; the connexion -ween the leading carriage on the rails and the travelling piston inside the being effected by a singular and extremely ingenious arrangement. The -aratus consists of a cylindrical cast iron tube, having a covered rectangular -nnel extending along its upper side. Along this channel, at intervals of about -eet, are fixed small square boxes, with standards to each to support a pair of -tical spindles, placed one on each side of the channel. On the lower end of spindle, within the boxes, and on a level with the channel, is fixed a pinion oblique teeth, and to the upper side of the travelling piston is attached a -or rack with similar teeth on each side; the progress of the piston brings -rack between the wheels, and turns the spindles round with great velocity. -the upper ends of the spindles are fixed pinions exactly like those below, and -he leading carriage is attached a rack similar to the piston rack. This upper - lies immediately over the lower or piston rack, and gears into the upper -ions, the advance of the piston, therefore, by imparting motion to the upper -ions, causes a corresponding advance of the carriage. Each rack is of -cient length to reach from one pair of pinions to another, and consequently -racks are always in gear with the pinions on one pair of spindles.

-he annexed cuts will help to render the foregoing description more in--igible.

-g. 1. is a cross section of the atmospheric main, *Fig.* 2, a section at the --, and *Fig.* 3. a longitudinal section of the main, with the piston and a -ion of the carriage racks; *a* is the tube, and *b* the rectangular covered -nnel extending along the upper side of the tube; *c c* are the spindles, and -the lower, and *e e* the upper, pinions fixed thereon; *f* is a valve to admit the -o the back of the piston, and *g* is the key by which it is raised; *h* is the --n, and *k* the piston rack which moves along the covered channel, and -ing into the lower pinions gives motion to the spindles; *m* is the external which is attached to the leading carriage, and gearing into the upper -ons, the carriage is impelled with the same velocity as the piston; this rack -s passage depresses the key *g*, which raises the valve *f*, by which the air is -itted to the back of the piston.

-g. 4 is a representation of the leading carriage with the whole of the -aratus.

-t cannot be denied that Mr. Pilbrow's arrangements exhibit great ingenuity -skill, but experience is wanting to show how far the system is adapted to the various exigences of railway traffic. The point on which failure is to be apprehended is precisely that on which the whole system depends, the mode of connecting the piston with the train. For the perfect working -e plan each pair of pinions should stand in such position that the teeth of -piston rack shall, on reaching the pinions, fall into the space between two of -pinion teeth, instead of encountering the teeth themselves; should the latter happen, the rack and pinions would be liable to become jammed, and a -ure of some part of the apparatus must ensue; but even supposing this -ction to be of no practical moment, still, when we consider the momentum -heavy train, which, moving with a velocity of 30 miles, comes in contact the pinions, which are at rest, it is to be feared that the teeth of the racks -pinions would soon be destroyed, or at least that a series of shocks would -place, as the racks became engaged with the pinions in succession, which prove highly unpleasant to passengers, and tend to check the velocity and -crease greatly the wear and tear of the carriages. Should these difficulties,

however, prove to be imaginary, or greatly overrated, we think it will be found to possess many of the advantages over the Samuda system which Mr. Pilbrow

Fig. 1.

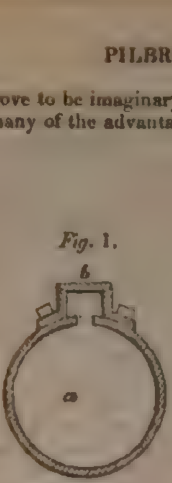


Fig. 2

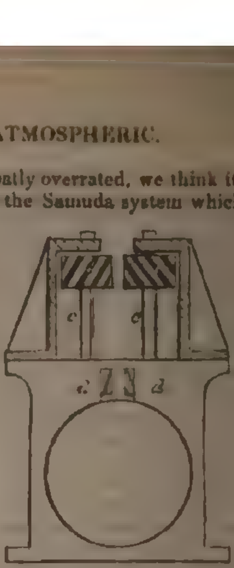


Fig. 3.

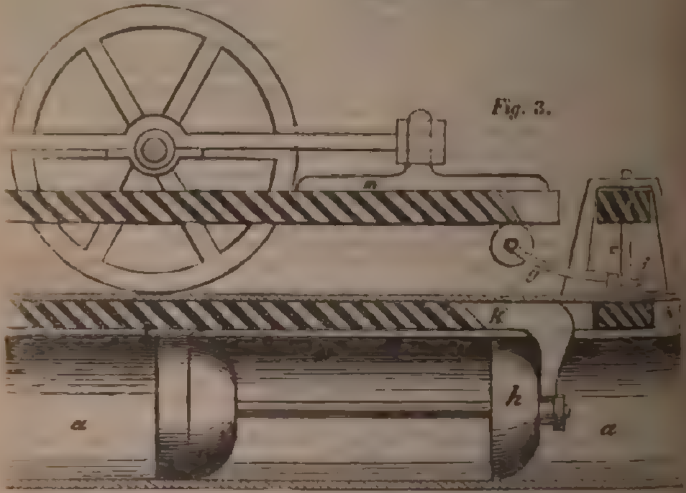


Fig. 4

has claimed for it in a pamphlet which he has published. Among the least disputable of these advantages are the following:—

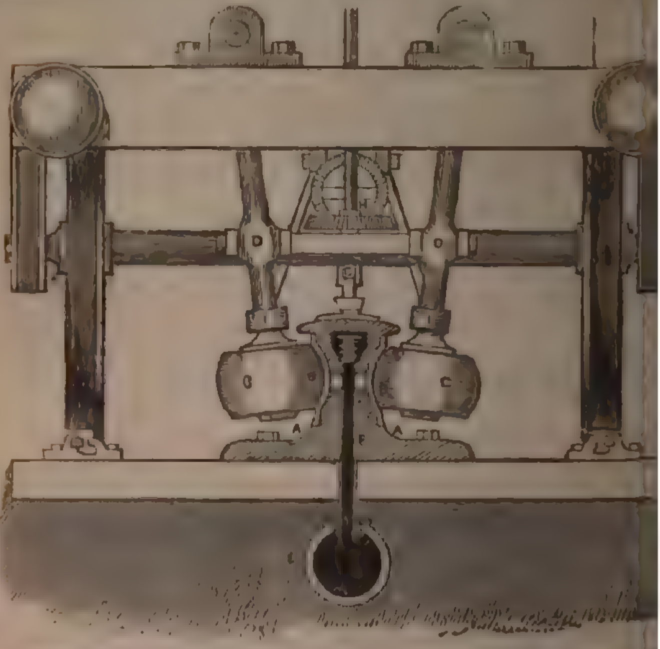
As regards facility and economy of construction; public roads may cross us on a level, whereby bridges are rendered unnecessary; no cranes or rails are required for taking carriages on or off the line, and different railway may cross each other at any required angle, (one tube passing the other tube,) which on Mr. Samuda's plan cannot be done. Mr. further claims a saving as regards the cost of his main, and also in the ce of expense between the continuous valve and his spindles and pinions, think this latter item more doubtful.

As regards the loss of power from leakage; the piston valves are less to leak than the continuous valves, as the former are ground into their and they expose a less surface at which leakage can take place; for the valve or seat is but about nine inches in circumference at the aperture the air is admitted, and there are but two of them to every 30 feet of $1\frac{1}{2}$ feet, whereas in the continuous valve the whole 30 feet is liable to ; hence, were the piston valves even to leak as much as the long valve, for surface, the leakage would amount to only one-twentieth of the of the continuous valve. From this circumstance Mr. Pilbrow assumes engine to every 10 miles will be found sufficient, whereby the number ne establishments upon a line would be greatly reduced: but leakage the only source of loss of power in the atmospheric tube; the resistance the friction of the air in the tube is very considerable, increasing rapidly length, and Mr. Herapath, from M. Mallet's experiments on the line, calculates that with a main $5\frac{3}{4}$ miles long, the engine could not the main to one half of that which it would if only $1\frac{1}{2}$ mile long; and nds, therefore, that nothing is gained in applying this system by employing mains than $1\frac{1}{2}$ mile, and is of opinion that mains of only a mile would powerful, command greater loads and velocities, and prove on the more economical.

and Nickels's Pneumatic Railway.—Messrs. Keene and Nickels have a novel system of railway locomotion, which is founded on principles not to have been hitherto applied to the communication of mechanical It differs from the atmospheric railway in this respect, that it is travelling piston as in Clegg's and Samuda's, and without racks and as in Pilbrow's invention: the carriage is propelled by the pressure of great velocity, and a tractive power is attained superior to that of the models on the same scale of either of the atmospheric railways. The g are the main details.

is laid under ground an air-tight chamber, or cast iron pipe, which the moving power, air condensed by forcing pumps to about three res: that is, the air in this chamber is compressed into one third of its under ordinary atmospheric pressure. Midway between the rails are gitudinally, at certain intervals, standing above the surface, squared of wood, or iron, say from twenty to thirty feet in length: the two sides of the beam are a little hollowed, and along these channels side is placed a tube of an elastic air tight material, susceptible of pansion and collapse. The expansible tubes communicate by inter- pipes, furnished with stop-cocks, with the reservoir of compressed air. the fixtures of the apparatus. Then, on the under side of the carriage oved are two solid drums, fixed on vertical spindles, which run in ng collars, and these drums are so placed, that when the carriage on its independent wheels upon the rails, passes over the horizontal they embrace the two vertical sides, and closely compress the lateral ubes, so as to leave no air passage beyond the point of contact. Now the carriage thus equipped to be stationary over that which we will interior extremity of one of the beams, from which point motion is to A stop-cock in the connecting tube is opened, and instantaneously a of the compressed air from the reservoir rushes by its expansive force two lateral flexible tubes, and meeting resistance on the line of com- of the two drums, it drives them, and consequently the carriage,

forward, following them with the same propulsive energy to the other e[illegible] of the beam. By this action the carriage has aquired such a momentum[illegible] carry it with the velocity required, onwards to the next beam, where the [illegible] is renewed, and thus repeated through the whole length of the line. T[illegible] brief description of the modus agendi of the system, which will ena[illegible] general reader to comprehend in what manner compressed air with an [illegible] pressure of forty pounds to the square inch, admitted through a pipe no[illegible] than 1½ inch in diameter, propels a carriage holding four persons with [illegible] velocity.



THE CUT REPRESENTS A TRANSVERSE SECTION OF THE APPARA[illegible]

A A, Iron Flange forming the inside of the valves, B B, Diaphragms composed of leath[illegible] and Gutta percha, forming outsides of valves; C C, Pinions turning on axes D D. E [illegible] containing compressed air; F, Spring tube for admitting the compressed air from the [illegible] to the interior of the valves; G, Skate for depressing the spring tube, H H. Gear for [illegible] depressing skate; I I. Rods for supporting pinions.

The Gutta percha above mentioned is a gum lately introduced from Si[illegible] it possesses properties which render it superior to caoutchouc; it is unin[illegible] heat or acids, is elastic, but possesses more tenacity; and at 212° F[illegible] can be moulded into any form, or two pieces can be kneaded toget[illegible] the fingers, and the joint made as strong as the original substance.

Hallette's Atmospheric Railway.—We shall now briefly describe [illegible] been generally termed "Hallette's system of atmospheric railway;" [illegible] strictly speaking, the system is not new, being in fact a combination [illegible] Pinkus's two plans, and the improvements consisting of modifications of [illegible] parts of the apparatus, chiefly the continuous valve, the piston, and t[illegible] of connecting a pneumatic locomotive engine with the pneumatic [illegible] proposed by Mr. Pinkus in his patent of 1836. Mr. Hallette's impro[illegible] form the subjects of two patents in this country, which were taken in t[illegible] of Mr. W. Newton. In his first patent Mr. Hallette employs a piston

ding in the air tube as proposed in Mr. Pinkus's first plan; but the longitudinal valve is on the principle of that proposed in Mr. Pinkus's second plan, already described, in which the slit is closed by two elastic plates of metal, extending the length of the tube; these plates in Mr. Hallette's plan being replaced by flexible hose, filled with air or water, or a portion of both.

Fig. 1 represents a transverse section of the tube, and of the arm by which the piston is connected with the leading carriage of the train; *fig.* 2 is a longitudinal section of the tube and piston; and *fig.* 3 is a plan of the tube and of the piston arm. *a* is the tube, having a slit or opening for the passage of the

Fig. 3.

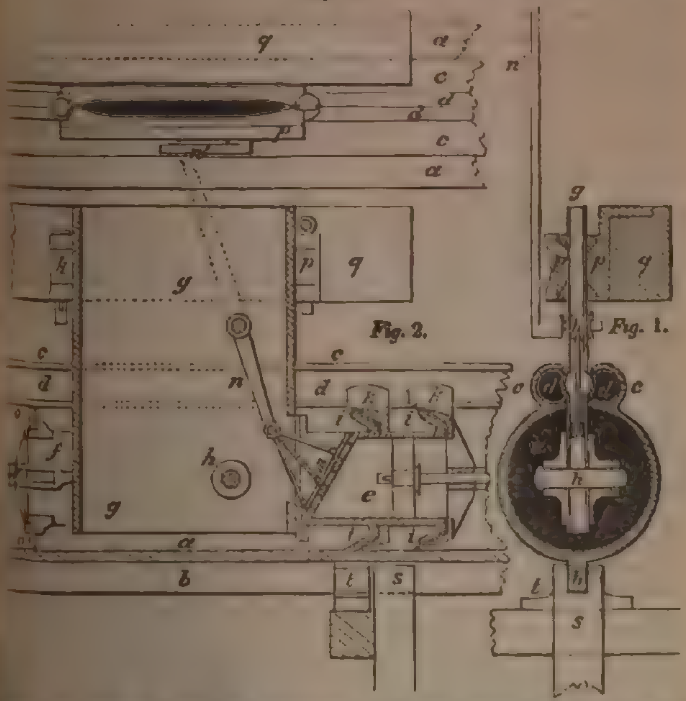


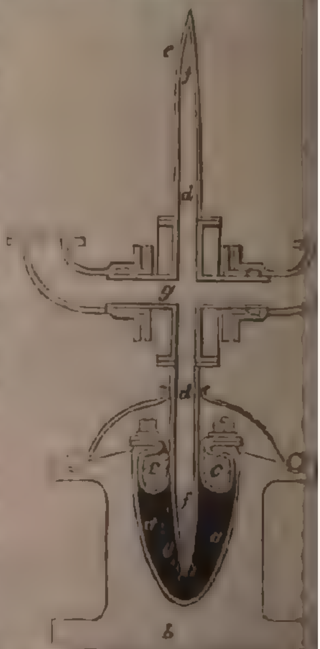
Fig. 2.

Fig. 1.

piston arm, extending along its upper side, and strengthened below by a rib, *b*. Along each side of the slit extends a semicircular trough or recess *c c*, cast upon the tube, and in each recess is lodged an air tight flexible tube or hose *d d*, filled with compressed air, and any suitable liquid; and the two hose lying in close contact with each other close hermetically the longitudinal slit. The travelling piston is composed of a short tube *e*, attached to a forked lever *f*, which receives within its fork the hollow arm *g*, and is jointed thereto by the pin *h*. The piston carries at its circumference two cupped leathers secured by rings at *i i*, to form an air-tight joint with the interior of the atmospheric main, and two pieces of brass at *k k*, which fill up the breadth of the slit, and prevent the passage of the air at that part into the vacuum in front of the piston. The piston is open at the fore end, but at the back it is closed by hinge valves *m m*, which are connected by rods to the lever *n n* (within the hollow arm), by means of which they can be raised when it is requisite to destroy the vacuum, in order to prevent the advance of the train. The piston is free to turn upon the pin *h*, being counterbalanced by the weight of the lever *f*, and the latter has several collars of stout leather, screwed up between two rings at *o o*, to deaden the

concussions which might arise from any irregularities in the level The hollow arm *g*, is made of wrought iron, and in its horizontal the form of a weaver's shuttle, as is shown in the plan. This arm to the leading carriage by a hinged clamp *p*, attached to a stout ba secured to the under side of the frame of the carriage. The atmo is not attached to the transverse sleepers which carry the rails, but upon a number of vertical posts *s*, driven into the ground midway rails, and having a notch in the upper end to receive the rib of the is steadied laterally by chairs *t*, bolted to the sleepers.

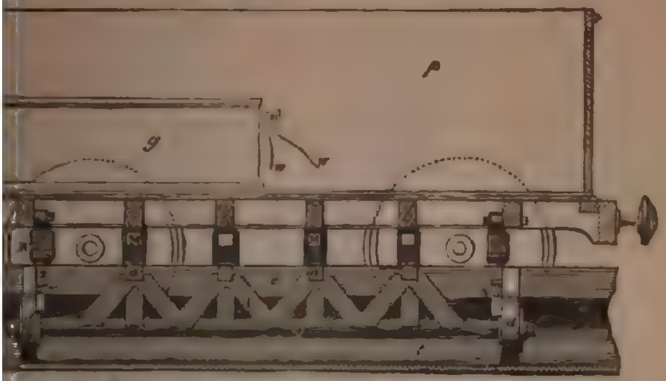
Mr. Hallette's second plan resembles in principle that of Mr. which a pneumatic locomotive was substituted for a steam locomotive matic engines communicating with the pneumatic main, in which was to be maintained; but Mr. Hallette proposes, instead of a vacu ploy compressed air. Mr. Hallette's chief improvements in the details consist, firstly, in the valve or apparatus for closing the longitudinal the tube; and secondly, an apparatus whereby the locomotives may with compressed air, without creating too much friction, and there those parts of the longitudinal valve with which the instrument comes



The accompanying figure represents a transverse section of the pneumatic tube, and the connecting apparatus *a*, is the pneumatic tube, formed of sheet iron, and supported by chairs *b*. The longitudinal groove is closed by means of two long cushions, *c*, the surfaces of which, when at rest, are by their own elasticity maintained in close contact with each other, and thereby prevent the passage of air between them, except when forced apart for the purpose of allowing the compressed air to enter the locomotive engines. These cushions are made of leather, and filled with a composition of gelatine and molasses, or any other suitable compound; and the edges of the tube are pinched between the doubled-over edge of the tube, and an iron band. *d* is a hollow disc, from 3 to 5 feet in diameter, and in its transverse section resembling a double convex lens. It is mounted on hollow axles *g*, which work in stuffing boxes, attached to the locomotive, and form a communication between the disc and the locomotive engines. periphery of the disc are a number of small apertures *e*, closed on th valves of soft leather *f*. The tube being filled with compressed a disc being inserted between the cushions, the air will force open th and instantly fill the disk with air of the same density, and as the di and finally passes out into the atmosphere, the compressed air with closes the valves, *f*, in which it is assisted by a spring. As the engine along the rails, the disc revolves between the cushions, which r advances and close upon it behind, so as to preclude the escape of pressed air within the tube, into the atmosphere; and to reduce t between the disc and the cushions, the latter are lubricated with a suet and powdered talc. The pneumatic tube is divided into sectio

…ing, and at the end of every section, a yard or two, with its cushions, …wn to the revolving disc, to enter and leave the tube more gradually. …ude our account of the atmospheric modes of propulsion, by a de… Taylor and Conder's patent electro-magnetic railway. This invention …he application of electro-magnetic power, to connect the piston car… …rain with the driving piston within the tube. *Fig.* 1 is a longi… …ion, and *Fig.* 2 a cross section of an atmospheric railway tube,

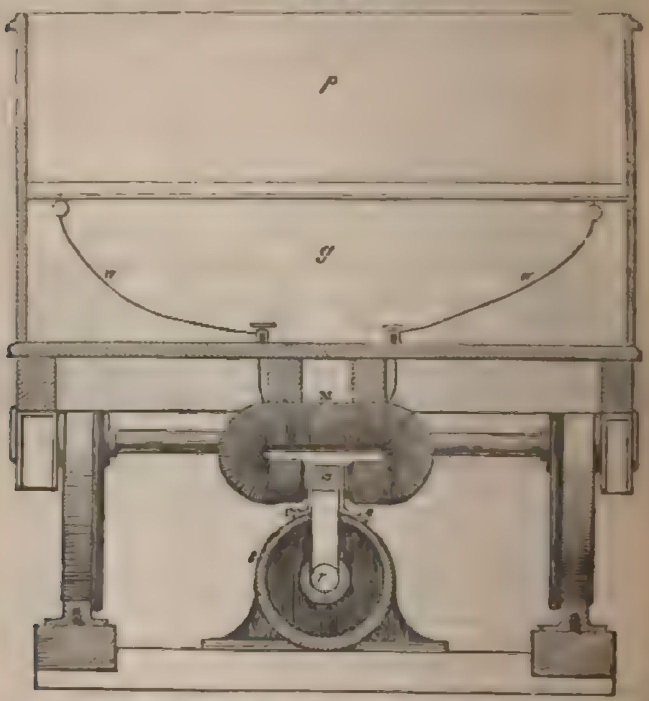
Fig. 1.



…carriage, showing the manner in which the connexion is effected. …, in the top of which there is a longitudinal slit or opening as usual, …arrower; *c* is a continuous air tight cover which is bolted down upon …inal slit. The tube *t* is of iron, but the cover *c* is made of copper, …ne other substance not susceptible of the electro-magnetic influence, …to the tube by copper bolts; *d* is the driving piston, which consists of … *d d*, of the same diameter as the interior of the tube (or nearly …ed by a rod *r*, which carries (as here shown) four upright square … *a*, called armatures, which project upwards through the top slit in …d fit into the square space within the cover *c*. These armatures … the upper part of some substance not susceptible of the electro… …fluence, as brass or wood, but capped at the top by pieces of iron, …copper bolts. *p* is the piston carriage, to the bottom of which there …(instead of the usual piston connecting rod) four electro-magnets … the peculiar form shown in *Fig.* 2, each of which presents its two … or poles to the sides of the cover *c*. The power of the magnets …eased by inclosing them in a tube or case of iron, leaving the extre… …ies open. *g* is a galvanic battery placed in the piston carriage, and … be of any approved form and of any required power; *w w* are …hich the battery is connected with the electro-magnets M M M M. …f action is as follows. Motion being given to the piston by exhaus… …or less) from the tube of the air in front of the piston, and the …ing at the same time connected with and excited by the battery, the … by induction on the iron armatures *a a a a* attached to the piston … come within the sphere of their attraction, (the cover *c* offering no … to that attraction, as it is of a substance not susceptible of electro… …uence,) whereby the magnets and the armatures become virtually …ether, and draw along with them whatever carriages may be at… … carriage which holds the magnets and battery. When it is desired … a train from the piston, this is effected instantaneously, by discon… … wires of the battery from the magnets. Instead of using one …set for each armature of the form before described, two ordinary …agnets may be employed, care being taken that the positive pole … magnet shall be placed opposite the negative pole of the other.

To allow air to pass through the piston as may occasionally be required, the discs *d d* of the piston are provided with valves *e e*, which are respectively connected to vertical iron spindles *s*, which terminate within the tube *t* immediately opposite small electro-magnets *m m* affixed beneath the carriages;

Fig. 2.



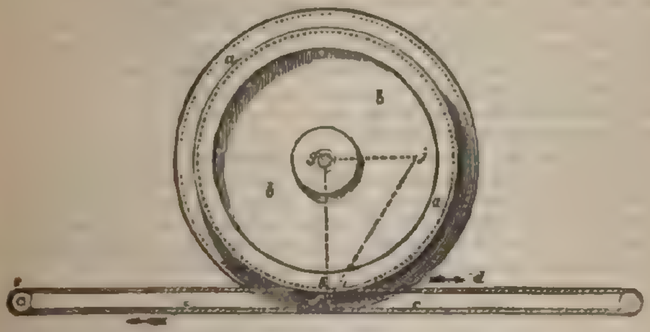
so that when it is desired to open either valve, all that is necessary is to excite the magnet which commands the spindle of the valve (by connecting it to the galvanic battery), on which the magnet will draw the spindle upwards, and thereby open the valve.

Saxton's Differential Pulley.—A very ingenious proposition for making use of the power of a horse, moving at his slow working pace, to communicate a high velocity to carriages upon a railway, through the medium of a new arrangement of pulleys and ropes, was invented by Mr. Joseph Saxton, of London, for which he obtained a patent, on the 20th June, 1833. The invention consists in the application of pulleys of different diameters, termed "differential pulleys;" the principle of the action of which will be comprehended by the following illustration:—

Fig. 1 (in the opposite page) represents a combination of two pulleys, their diameters being as 6 to 7; *a* being the larger pulley, and *b* the smaller one. *c d* is an endless rope, passing over the sheaves *e e*; the part *c* of the endless rope first takes a turn round the larger pulley *a*, and the part *d* also takes a turn round the smaller pulley *b*. If then the rope *d* be moved in the direction of the upper arrow, it will draw the lower part of the pulley *b* in the same direction; meanwhile, the part *c* of the endless rope will be moving in the direction of the lower arrow, and will move the lower part of the pulley *a* in the same direction with this part of the rope; consequently, the two pulleys *a b* (which are fixed together) would turn on the mean point *f*, as a fulcrum:

g is the centre of the two pulleys. Let it then be supposed, that the part d of the endless rope be moved from h to i, it will be evident that the centre g of the differential pulleys a b would be moved to the point j, and, consequently, if any object were connected to the centre g of those differential

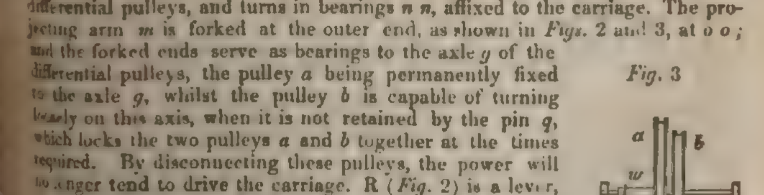
Fig. 1.



pulleys, it would be propelled from g to j, by the endless rope c d being moved the much smaller distance of h to i, indicated by the dotted lines; and these distances will be as 13 to 1.

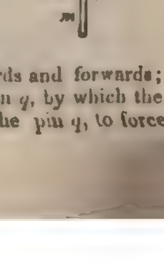
Fig. 2 represents the contrivance applied to an ordinary carriage, having four wheels, as usual, two of which, k k, are shown. a and b are the differential pulleys, placed on an axis g (see *Fig.* 3); m is a frame which carries the

Fig. 2.



differential pulleys, and turns in bearings n n, affixed to the carriage. The projecting arm m is forked at the outer end, as shown in *Figs.* 2 and 3, at o o; and the forked ends serve as bearings to the axle g of the differential pulleys, the pulley a being permanently fixed to the axle g, whilst the pulley b is capable of turning freely on this axis, when it is not retained by the pin q, which locks the two pulleys a and b together at the times required. By disconnecting these pulleys, the power will no longer tend to drive the carriage. R (*Fig.* 2) is a lever, turning on a fulcrum S: the upper end of this lever is formed into a handle, and placed under the control of a person sitting in front of the carriage; the other end of this lever receives the flanch of a sliding socket l within it, as shown in *Fig.* 2; u is a bent lever, having its fulcrum at v, on the forked frame o, as shown in *Fig.* 3. One end of this cranked lever u has a crotch, which receives the flanch l of the sliding socket; and the other end of the lever u has also a crotch to slide the socket w, on the axis g, backwards and forwards; s is an arm, fixed to the sliding socket w, and carrying the pin q, by which the wheels b are fastened together: a spiral spring is placed on the pin q, to force

Fig. 3



it in, when a part of the pulley which is cut away comes opposite to the belt; there is also a spring to prevent a sudden concussion. In *Fig* 2, *c d* is an endless rope, the part *c* taking a turn round the pulley *a*, and the part *d* taking a turn round the pulley *b*, as described in *Fig*. 1. This endless rope is supported, at proper intervals of the road, on sheaves, and passes round a rigger at each end, to which is attached an apparatus for preserving it sufficiently tight. Now suppose the pin *q* to be passed through the two pulleys *a b*, to retain them together, and the endless rope *d* be moved in the direction of the arrow, a similar action will take place to that described in *Fig*. 1; that is, the carriage (being attached to the centre *g* of the differential pulleys *a* and *b*) will be propelled forward on a railway with a much greater velocity than the rope travels; and the distance so travelled by the carriage, in comparison with that through which the rope moves, will depend on the differences of the diameters of the pulleys *a b;* and the nearer the respective diameters of the pulleys approach each other, the greater will be the relative velocity the carriage will travel, to the velocity with which the rope moves. In order to prevent the two parts of the rope rubbing against each other, in leading on and off the differential pulleys, the axis *g* of these pulleys is placed at an angle a little varying from a right angle with the direction of the motion of the carriage.

Fig. 4.

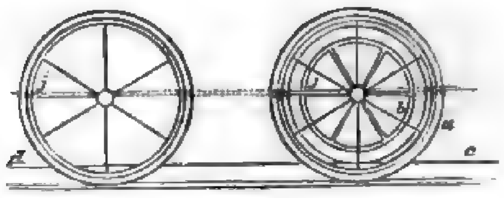
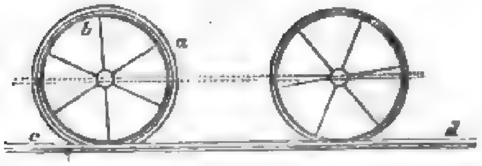


Fig. 5.



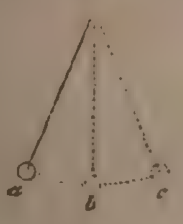
Figs. 4 and 5 show two different applications of the invention from that shown in *Fig*. 2; for in these instances there is only one pulley, whilst the two front or two back wheels of the carriage act the part of the other pulley. In *Fig*. 4, *a* is one of the front wheels of the carriage, which also acts as the larger pulley; *b* is the smaller pulley, and is the only one around which the rope *c d* passes; the wheels *a*, and the pulley *b*, being on the same axis *g*, which runs from side to side of the carriage, and turns in bearings affixed to the carriage. In this arrangement the point *f*, at which the wheels touch the rail, becomes the fulcrum on which the wheel *a* turns; and it will thus be evident that if the rope *c d* be drawn forward in the direction of the arrow, a similar effect will be produced as described in *Fig*. 2, and as shown in dotted lines in *Fig*. 4. Nevertheless, if the wheels and pulleys *a* and *b* be of the same relative diameters as those in *Fig*. 2, the carriage at *Fig*. 4 would only be propelled at the velocity of seven to one, owing to the fulcrum, at which the wheels *a* turn, being removed from the mean point *f*, *Fig*. 2, between the two diameters, and placed at the extreme end of a radiating line, drawn from the centre of the wheel *a* to the point at which it touches the railway. In *Fig*. 5 the rope is passed around the pulley *a*, which is the larger, whilst the carriage-wheels act the part of the smaller pulley *b*, the pulley *a* and the wheels *b* being on the same axis *g*. In order that the pulleys in this arrangement may stand at an angle for clearing

the axle *g* is formed of three parts, connected by universal joints; of the wheels *b* thus travels a little forwarder than the other, and thus will clear itself. And it should be observed, that in both these arrangements, the pulley around which the rope passes is to be made capable of disconnected from revolving with the axle as described in *Figs.* 2 and 3. arrangement, *Fig.* 5, the fulcrum *f*, on which the wheels turn, is the which the wheel *b* touches the rail or road; and the difference in the ments, *Figs.* 4 and 5, is, that the power in *Fig* 4 is applied by the rope the fulcrum *f*, and the centre *g*, of the wheels or pulley *a b*, where the be drawn is attached: whilst in *Fig.* 5, the fulcrum is between the the pulley and wheels *a*; consequently, the arrangements differ in the leverage, and, in this instance, will be as six to one. In these two last ments, the rope *c d* may be either an endless rope, as described in *Figs.* or the rope may be single, and, taking a turn around the pulley *a* or *b*, wound on a drum at each end of the distance which is to be run by th of a rope.

ll's undulating Railway.—A very singular and interesting proposition made by Mr. Richard Badnall, for travelling upon undulating lines ay in preference to straight or level lines, with the view of saving ve power, by the application of the natural force of gravity in the so as to obtain a great momentum in making the succeeding ascent. is best explained by himself in the specification of a patent, dated the ptember, 1832, which he obtained for that object.

plummet suspended by a string, (as in *Fig.* 1 in the annexed engrav- the point *z*, be drawn away from the perpendicular line to the point here let go, it will fall by its gravity to *b*, in the arc *a b*; but, in its

Fig. 1.



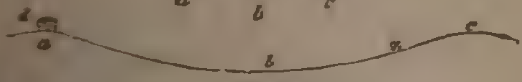


Fig. 2.

it will have acquired so much momentum, as will carry it forward up lar altitude at the point *c*.

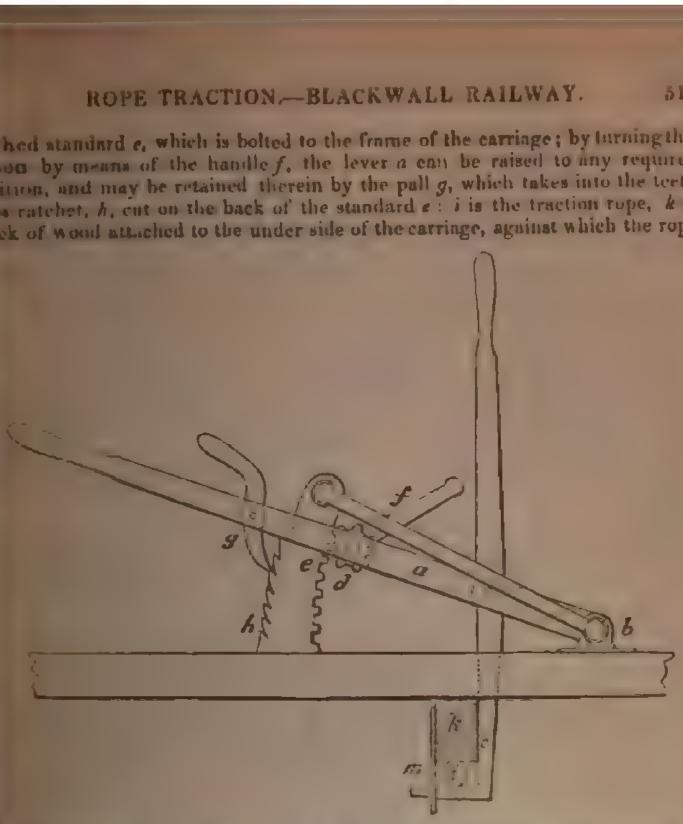
it be supposed that a line of rails, or tram-way for carriages, be so con- from the summit of two hills, as *Fig.* 2, across a valley, that the descent hill, as *a*, to the valley *b*, shall subtend a similar angle from the hori- ne to the ascent up the other hill from *b* to *c*. Now if a train-waggon, placed at the summit of the declivity *a*, it will, by its gravity alone, run descending line of rails, to the lowest point *b*; but in so running, to the principles of the oscillating pendulum, it should have acquired ntum that would carry it forward without any additional force up the line to the summit of the hill *c*, being at the same altitude as the It is quite certain that this would really take place if the force acquired momentum was not impeded by the friction of the wheels of the carriage ir axles, and upon the rails on which they run. Hence, subtracting nt of friction as a retarding force from the momentum which the car- acquired in descending from *a* to *b*, it will be perceived, that the force ntum alone would only impel the carriage part of the way up the

ascent *b c*, say as far as *x*. It must now be evident, the carriage *d* would no only pass down the descending line of road from *a* to *b* by its gravity, but that the momentum acquired in the descent would also impel it up the second hill as far as *x*, unassisted by any locomotive power. In order, therefore, to raise the carriage to the top of the second hill, I have only to employ such an impelling force as would be sufficient to drive it from *x* to *c*, the whole expense of locomotive power for bringing the carriage from *a* to *x* being saved. If now I employ a locomotive power to assist in impelling my carriage from *a* to *b*, I, by that means, obtain a greater momentum than would result from the descent of the carriage by gravity alone, and am enabled by that means to surmount the hill *c*, having travelled the whole distance from *a* to *c*, on the undulating line of road, with the exertion of much less locomotive power than would have been requisite to have impelled the carriage the same distance upon a perfectly horizontal plane." Having thus explained the principle of his invention, Mr. Badnall claims the formation of tram and railroads, with such undulating curves as are adapted to his object. This invention has been the subject of much able controversy in the *Mechanics' Magazine*, and some other public journals, of which our limits render it impossible to give any account. The plausible arguments which were raised in support of the inventor's theory, led to some public trials on the Manchester and Liverpool railway; which, although conclusive as to its inefficacy in the minds of most persons who doubted before, has apparently had the effect of confirming the patentee in his prepossessions of its utility.

Rope traction.—Blackwall Railway.—On the Blackwall railway the traffic is carried on by means of ropes worked by stationary engines, erected at each end of the line. This system has been adopted on account of the number of intermediate stations along the line, the line being only about 3½ miles long, and having five intermediate stations. And had locomotives been employed, the time lost in stopping and starting the trains would have exceeded that occupied in traversing the lines. The line is worked as follows:—supposing the train to be that which is passing from London to Blackwall; at each of the intermediate stations is one or more carriages, for the conveyance of the passengers from those stations to the Blackwall terminus, and at the London terminus is ranged what may be termed "the train," consisting of one or more carriages for the Blackwall terminus, and one or more for each of the intermediate stations; the Blackwall carriages being the first in the train, and those for the intermediate stations being ranged in the order of the proximity of the stations to the Blackwall terminus. The several carriages being attached to the rope, the engine at the Blackwall end of the line is put in motion, and the carriages from the intermediate stations arrive in succession, at intervals, at the Blackwall terminus; the carriages, being detached from the rope (without stopping the rope) as they successively arrive within a certain distance of the terminus, and being stopped at the proper point by a powerful brake attached to each carriage. In like manner the carriages for the first intermediate station from London (and which carriages will be the last in the train) will be detached from the rope as they arrive within the prescribed distance from the station, and so on with the carriages for the remaining stations, until the leading carriages from London arrive at the Blackwall terminus, which completes the operation, and the rope is then stopped. This system of working the line has the advantage of delivering the passengers at each intermediate station without detention to the other carriages, but it is attended with this inconvenience, that the intermediate stations have no communication one with the other, but only with the termini: for instance, a person could not proceed from Stepney to Poplar, but would have to go on to the Blackwall terminus.

The accompanying figure represents the apparatus for attaching the carriages to the rope, which combines the advantage of a powerful grip with a ready means of casting off the rope. *a* is a forked lever turning upon a fulcrum at *b*, at the fore end of the carriage, and carrying within the fork the hanging clutch or nipper *c*; *d* is a pinion supported by the lever *a*, and working in a

othed standard *e*, which is bolted to the frame of the carriage; by turning this nion by means of the handle *f*, the lever *a* can be raised to any required sition, and may be retained therein by the pall *g*, which takes into the teeth a ratchet, *h*, cut on the back of the standard *e*: *i* is the traction rope, *k* a ock of wood attached to the under side of the carriage, against which the rope



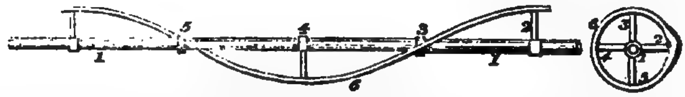
is firmly jammed when in action: *m*, is a forked cheekpiece attached to the side of the block to prevent the rope flying off laterally. When the rope is detached, the apparatus assumes the position indicated by the dotted lines. To attach the carriage the rope is lifted on to the claw of the nipper, which is then thrown into a vertical position, and the lever *a* is wound up until the rope is bound firmly to the block, and the pall *g* is put down. To release the rope, the pall is thrown back, and the lever *a* falls into a horizontal position, and the nipper being thrown into the inclined position shown by the dotted lines, the rope is thrown off.

The railway is worked by two pairs of stationary engines, of 400 and of 200 horse-power respectively, at the Minories and Blackwall termini. The ropes are not worked on the plan of endless ropes, but there are two distinct ropes, one to each line, extending along the length of the railway, guided by grooved pulleys, and coiled round drums, twenty-two feet in diameter, situated at each end of the line, and worked by the engines; the one drum giving out the rope as fast as the other winds it up, so that each rope is twice the length of the railway. The drums are formed like sheaves, or pulleys, with a very deep groove, which becomes gradually narrower as it approaches the centre, so that the rope, when coiled upon the drum, forms numerous layers; and this tends in some measure to equalize the load upon the engines; for, at starting, when the number of carriages is greatest, the virtual diameter of the drum is least, and the advance of the train during a revolution of the drum is, consequently, least, but, as the train advances and becomes lighter, by a portion of the carriages being detached as they successively arrive at the intermediate stations, the virtual diameter of the drum is increased by the additional layers of rope it has received, and the speed is consequently proportionately increased. The carriages run each way upon each line; and the signals for starting, and the general working of the train line, are given by the electric telegraph. At first, hempen ropes were employed, but, owing to the inconvenience and delay

occasioned by their frequent breakage, wire ropes, with swivels at given distances, have been substituted; and now, in about 2,000 journeys each way per month, not above two fractures occur. The wire rope now used is formed of six strands laid round a hempen core, and each strand is composed of six wires, also laid round a hempen core. In a paper by Mr. A. J. Robertson, read at the Institution of Civil Engineers, it is stated, that the power to move the rope alone was about 200 horse power, for a hempen rope, and with the wire rope, on account of its greater weight, it required about 250 horse power. The expense of working the engine and rope is stated to be about fourteen-pence per train per mile, but the author observes that the question of expense must not be considered abstractedly; it must be remembered that the traffic could not be carried on at the requisite speed by locomotive engines if they had required to stop seven times in 3½ miles,—it was, therefore, a question, whether the system of rope traction, by which the traffic could be carried at a given speed, or whether the intermediate traffic, should be abandoned. The latter, commercially speaking, could not be done, and the rope system is therefore persevered in.*

Farrell's Patent Archimedean Railway.—This invention appears to possess considerable originality as well as ingenuity; but whether it can be made to work on the great scale, as well as we are told it does in the model, is a question upon which great doubts will be entertained, until experience shall decide it. The patentee distinguishes his scheme from all other plans of propulsion on railways by the term *Archimedean;* and he designates his chief movement the "screw propeller." Both these terms are calculated, in our opinion, to impress an erroneous idea. We should rather describe it as a *helix* of uniform obliquity, not connected solidly to the axis (as screws are), but with a space of about eight inches between one and the other; the connexion between the two being effected by a series of radiating arms, at about three feet distance apart throughout the entire line of railway. The annexed diagrams will make this construction quite clear.

Fig. 2. *Fig.* 1.



The above *Fig.* 1 is an end view of the helical propeller, and *Fig.* 2 is a side or longitudinal view. In the centre 1 1 is represented the tubular axis; 2, 3, 4, and 5, are the arms of the propeller, and 6 shows the helix, winding round the axis. These parts are very nearly in their true proportion: it is intended to make the propeller in twelve feet lengths, and the diagram shows one of such lengths throughout which the helix makes but a single revolution. Thus every revolution of the screw is designed to propel the train of carriages twelve feet along the rails. Having premised thus much to explain the construction of the "Archimedean screw," we shall avail ourselves of the patentee's specification in our further description, which has reference to the engravings which follow.

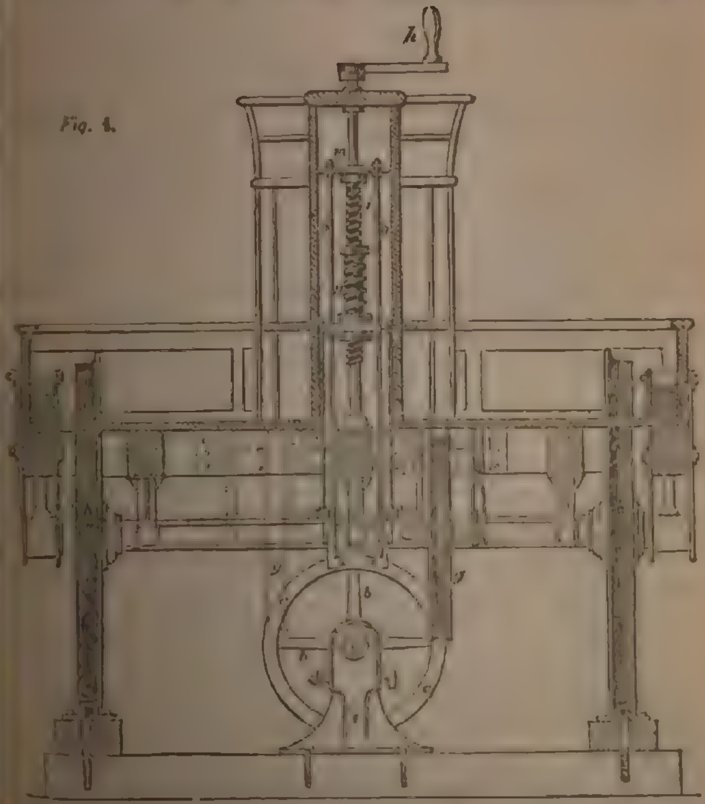
"This invention consists in the use and application of a screw, *a b c* (*Fig.* 3 subjoined), which is called the "screw propeller," for the purpose of locomotion on railways, and by means of which the moving power is communicated to the trains. This screw is laid down continuously in the middle of the track, and is fixed in the direction of its length, but caused to revolve upon its axis by steam or any other power communicated to it at proper intervals,—say every three miles along the line. This screw may be of any given diameter, say from eighteen to twenty-four inches, formed in lengths of from twelve to fifteen feet each, and consists of a shaft *a* of cast or rolled iron tubing, four inches in diameter, supporting by means of wrought iron arms *b b*, keyed on to the shaft, a rolled

* Since the above was written, it has been decided to discontinue the use of the ropes, and substitute locomotive engines for them.

on spiral *c*, which is bolted to the ends of the arms; the construction is such as to afford perfect confidence in its strength for its intended purpose. The

Fig. 3.

Fig. 4.



lengths of shafting are connected by couplings, that allow a sufficient play to correct any accidental irregularity in the line, and also to permit them to be laid

down on the quickest curves that are allowable on railways, with scarcely any calculable amount of friction: each length rests on turned bearings, in proper metal pedestals *e*, secured to the cross sleepers of the railway. The power is communicated to the screw *a b c* by means of spur wheels, fixed on one end of each line of shafting of one and a half mile in length, which is situated so as to drive two such lines, that is, one in each direction from it, and the gearing is so contrived as gradually to bring the screw propeller into motion, and also to transfer the power from one line to the other without stopping the train.

The motion of the screw propeller is communicated to the trains by means of a pair of wheels or rollers *g g*, so attached to the frame-work of the leading carriage of the train as to bear upon the rim *a*, spiral rail *c*, that forms the thread of the screw, one wheel being at either side of the axis of the screw; the position and arrangement of these wheels *g g* is such, that while one is propelled by being borne against by the thread of the screw, and carries the train forward, the other acts as a check wheel, and prevents the train from moving with an unequal motion, or running forward by acquiring acceleration; and the screw propeller being capable of acting in both directions, when the motion is reversed, that which before acted as a check wheel becomes the propelling wheel, and *vice versa*.

These wheels *g g*, which form the only connexion between the trains and the propeller, are perfectly under the control of the conductor, who, by turning the handle *h* of the vertical screw *i*, compresses the wheels *g g*, when he thinks it necessary, with more power upon the screw propeller, or in a moment disengage them from it, and having done so, can instantly apply the break, by continuing the same movement of the vertical screw *i*, which causes the nuts to press the cross beam *m* upwards, and bring down the break by means of the suspension rods *o o*, upon the bearing wheels. Thus, the train may be stopped at any points, without interfering with the motion of the propellor.

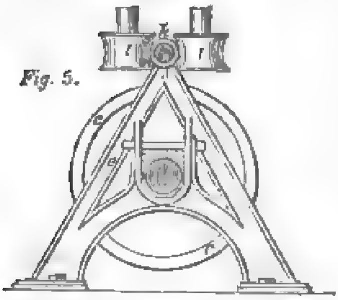
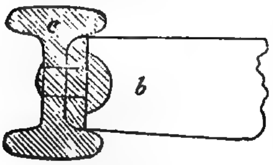


Fig. 5.

In addition to what has been already described, there is a provision in this invention, for dispensing with the flanges on the bearing wheels, and also for conveying intelligence or signals from station to station. This arrangement is shown in the subjoined diagram, *Fig.* 5; in this case, the bearing saddles *e*, are triangles the full height of the propeller, and a guide rail *k* is laid the whole length over the propeller; this rail is made of iron tubing, in lengths equal to the propeller, and fastened or screwed into sockets cast on the apex of the triangular bearing saddle *e*; against the guide rails, the friction rollers *l l* run, and the flanges on the bearing wheels are thus dispensed with; the rails may then be reduced to a flat iron bar. It is proposed that signals be conducted through the tube *k* from station to station.



The annexed figure is added, to explain the means of connecting the spiral *c* to the arms *b* of the propeller; the latter has a flange turning at right angles, through which a rivet is passed, as well as the spiral *c*, when they are both strongly united by riveting.

The advantage proposed to be derived from this invention, are, economy in the construction of railways, from the facility it affords for ascending inclined planes of almost any angle, and the consequent reduction of cuttings, embankments, bridges, &c.; also, in the use of light rails instead of the heavy rails required for the locomotive system; and in the use of lighter carriages than those at present in use, and hence, less useless load.

Economy of power for locomotion, by the use of fixed engines, or water power in place of locomotive engines, and the consequent avoidance of the expense of erection and support of those costly establishments required for the latter.

Safety to passengers, by collision or the running of the trains off the rails being rendered impossible.

Before proceeding to give an estimate of the expense of construction, or of power for locomotion, on this system, it may be well to consider for a moment the amount of friction due to such a line of shafting as I propose, and also its power of resistance to tortion.

On the subject of friction, a good deal has been written, and many experiments are recorded, but I prefer taking my data from actual observation: I have therefore made several experiments on different lengths of shafting, some very favourable in their results, and others the reverse; the most unfavourable was one consisting of four different lengths at right angles to each other, and coupled by bevel-wheels; the result was something less than the $\frac{1}{18}$th of the load, or 120lbs. to the ton. I take this, being the least favourable, as the standard upon which the following calculations are taken.

The weight of a mile and a half of the screw propeller, including gearing, will not exceed 80 tons, which at 120lbs. to the ton, leaves 9,600lbs. as the amount of friction; the bearings are 3 inches, and the pinion on the end of the shaft to which the power is applied 18 inches diameter, or as 6 to 1; therefore the power required to turn a line of shafting 80 tons weight, from a state of rest, applied at the periphery of the 18-inch pinion is 1,600lbs., or $\frac{1}{6}$th of 9,600lbs. The shafting is proposed to be formed of iron tubing, 4 inches diameter, and half an inch in thickness; the weight found by accurate calculation, and proved by experiment, as sufficient to twist such a shaft if applied to the periphery of an 18-inch pinion fast on it, is 22,196lbs.; now, as half the breaking weight may be applied, without producing any deflection, we have a shaft to which we may apply 11,100lbs. at the periphery of an 18-inch wheel, with perfect safety, without producing any tortion whatever. Now the power required to turn a mile and a half of screw propeller, from a state of rest, is 1,600lbs., which is about $\frac{1}{7}$th of the power that may with perfect safety be applied to the 18-inch pinion, or, in other words, the shafting might be extended to seven times the length I have proposed without being subject to any tortion whatever.

With respect to the applicability of this system to curves, let us suppose the propeller to be laid down on a curve of 1,320 feet, or one quarter mile radius, and the shafting in lengths of 12 feet, it is evident that each length of shafting will form the base of an isosceles triangle, whose sides are 1,320 feet and base 12 feet, or as 110 to 1.

On calculating the angles at the base of this triangle, it will be found that the friction of the couplings, which are 3 inches diameter, will be something less than $\frac{1}{36}$th of an inch, or $\frac{1}{110}$th part of 3 inches.

Again, although the curve is formed of a series of straight pieces, 12 feet long each, yet as the versed sine of the arc of which the 12 feet length forms the chord is but a small fraction more than one quarter of an inch, it will be seen that so small a deviation from the curve cannot be so much as felt in practice.

With respect to the power required for this system, it has been shown that 1,600 lbs. applied to the periphery of an 18-inch pinion will be sufficient to overcome the inertia of a mile and a half of propeller, and set it in motion, round its axis. Now suppose the pitch of the screw to be 12 feet, then every revolution it makes on its axis impels the train 12 feet, and 154 revolutions per minute will impel the train at the rate of 21 miles an hour; to obtain this speed we require a spur wheel $5\frac{1}{2}$ times the diameter of the pinion, or 8 feet 3 inches in diameter, making 28 revolutions in a minute. If this spur wheel is turned by a 2 feet crank, the radius of wheel being 4 feet $1\frac{1}{2}$ inch, it follows, that in order to apply a power equal to 1,600 lbs. at the periphery of the spur wheel, we must apply twice and one-sixteenth of that power, 3,300 lbs., to the crank; this

power would be afforded by a condensing engine, 24-inch cylinder, 4 feet stroke, and making 28 strokes per minute, or 18 horse power.

The foregoing calculations are made without any reference to the provision spoken of, for bringing the propeller gradually into motion; but as such provision is made, and it is known that half the power that is required to set a machine in motion is sufficient to continue that motion, we may safely calculate on one half the power above stated, or 800 lbs., as available for the purpose of propelling the trains. Now, as the circumference of the pinion is 4 feet 6 inches, and the pitch of the screw 12 feet, the effect will be as $4\frac{1}{2}$ to 12, and taking the friction of the train as 9 lbs. per ton, we have a power equal to the propulsion of $33\frac{1}{3}$ tons, or eight loaded carriages of more than 4 tons each; but as one of the great advantages this system possesses over any other, is the facility it affords for transmitting a succession of trains at very short intervals, provision may thus be made for the most extensive traffic without increasing the engine power: for instance, a train capable of carrying 50 tons on the present system, could be divided into four trains of five or six carriages each at ten minutes intervals, an arrangement by which 900 tons of goods, or 12,000 passengers, might be conveyed in a day of twelve hours, and the expense of locomotion not exceeding six shillings per day, as may be seen by the following estimate, which includes interest on capital sunk in engines, engine-houses, and machinery, and the daily expense of locomotion.

Estimate of one mile of screw propeller.	£	s.	d.
33 tons cast iron shafting, including the bearings and fitting the coupling joints, at £10	330	0	0
17 tons, wrought and rolled iron, in arms and spiral, the arms driven on hot and keyed, and the spiral secured to the arms with hot rivets, at £17 10*s*. . .	297	10	0
10 tons of cast iron, in saddles or pedestals, by which the propeller is supported, at £7	70	0	0
1 ton of wrought iron in screws, pins and keys . . .	20	10	0
1,760 yards of screw propeller laid down for fixing, bushings and sundries, at 1*s*. 6*d*.	132	0	0
	£850	0	0

Estimate of power for locomotion on three miles of double line of railway.			
1 steam engine, 20 horse power, or two 10 horse engines, including gearing, at £30	£600	0	0
Engine house and sundries	250	0	0
	£850	0	0

Interest on £850, at 5 per cent. per annum	£42	10	0
Coals for one 20 horse engine, working 12 hours per day, 365 days at 8*s*. per day	146	0	0
Attendance, wear and tear, and sundries	150	0	0
Apparatus connected with the carriages	50	0	0
	£388	10	0
	64	15	0
Interest on £850, the first cost of propeller at 5 per cent.	42	10	0
Total annual expense of one mile . .	£107	5	0

Thus the total expense of locomotion for a single mile for one year is £107 5*s*. 0*d*. not quite 6 shillings per day of 12 hours. The foregoing estimates show the expense of the system, as applied to any part of the present railways of

that in any new railway formed with reference to the application of this system, the saving on the rails alone will pay more than one half the cost of the propeller; and the saving in cuttings and embankments, bridges, &c. will render the formation of railways on this system scarcely, if at all, more expensive than a turnpike road.

The following is an estimate of the upper works of the Archimedean system complete, compared with the locomotive system, omitting those items that are common to both.

ARCHIMEDEAN SYSTEM.

		£	s.	d.
Cost of one mile of propeller as before detailed . . .		850	0	0
26 tons of cast iron tubing in guide rails at	£10 0 0	260	0	0
10 tons of cast iron in additional weight of bearing saddles, at	7 0 0	70	0	0
13,640 feet lineal of longitudinal and cross sleepers of Paynized wood, including laying, at . . .	0 1 6	1023	0	0
1,800 screw bolts and nuts, at	0 0 2	15	0	0
Cost of a single mile		£2218	0	0

LOCOMOTIVE SYSTEM.

		£	s.	d.
13,640 lineal of longitudinal and cross sleepers, including laying, at	0 1 4	£909	6	8
Rolled iron rails, 80lbs. per yard, 126 tons, including laying, the rails, at	£10 0 0	1260	0	0
8,840 screw bolts and nuts, in rails and sleepers	0 0 2	73	13	4
Cost of a single mile		£2243	0	0

From the foregoing it may be seen, that the expense of the Archimedean system complete, including (Paynized) wooden sleepers, will not exceed the cost of the upper works of the present locomotive system; that the expense of power for locomotion, for 12 hours continuous traffic, will be less than £65 per mile, per annum; and if it shall be found advisable to double the engine power that I allow, and thus work three miles of propeller at the same time, instead of 1½ mile, by which means the traffic may also be doubled, the annual cost will not amount to £100 per mile of single line, or £200 per mile of double line; while the cost of power on the locomotive system may be taken at an average of £1000 per mile, but on short lines, and where there is large traffic, it far exceeds that sum.

I would in conclusion observe, that all that has been said in reference to the saving that may be effected in cutting embankments, bridges, &c., in the formation of railroads adapted to the atmospheric principle, applies equally to the Archimedean: that saving will be great on the most favourable lines, and in many cases it will amount to thousands of pounds per mile.

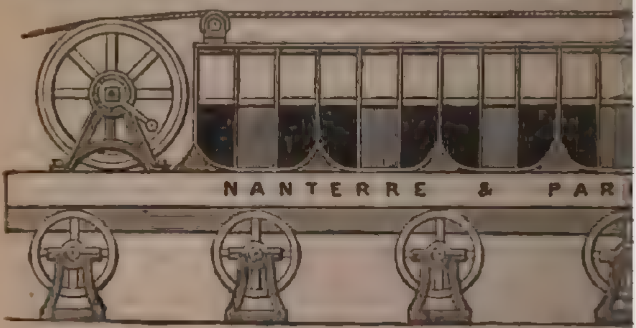
Parkin's Windmill Railway.—Amongst the numerous suggestions for new modes of propulsion, that proposed by Mr. Thomas Parkin is one which the ill informed portion of the public have been led to believe would supersede the use of locomotive and stationary steam engines. The contempt with which Mr. Parkin treats these latter is somewhat amusing. Speaking of a locomotive engine, he says, " it is obnoxious to fearful casualties. Now and then it breaks axles and wheels, and tears up rails, involving consequences so dreadful as to render even allusion to them painful; and it has, on these accounts, too justly been compared to the arch-fiend himself in harness. The weight of a locomotive also constantly injures the road, and subjects it to the necessity of frequent reconstruction; and when it is occasionally out of breath, the discovery is made that it sometimes amuses itself in polishing the rails, instead of making the best of its way home! For all the purposes of locomotion, an enormous fire (which now and then sets trains, standing corn, ricks, farm-yards, and other buildings in a blaze!) is made, and kept up, in order to have a constant

enormous supply of boiling water, (which now and then scalds men
the vapour whereof is confined in an iron case, and gives mo
unable to burst the case) to a piston, which turns a crank,
the 'driving' wheels of the engine, and this is designated *the locom*
but where is the fulcrum? Ay, that is the question! Why, the engin
had as much difficulty in finding a fulcrum for this lever, as
experienced in finding one to lift the globe, *have contented themsel*
weight of the engine for a fulcrum!"

After much similar sneering at the most extensively useful
modern times, our inventor proceeds to describe what he calls *the*
(and we prefer his description to our own, for obvious reasons): he

"Having disposed of locomotives and tenders, and developed
existing railways, we are brought to the new system of locomo
dispenses with tunnels, bridges, rails, steam-tenders, and carriages
and springs, and requires very little land to be bought, and very
work to be done.

"The road is formed of parallel lines of stanchions, mounted
on which a platform glides, carriages being built thereon, and ribs
are its guide. A small amount of power only is required to give m
platform, and the saving in the construction of this mode of co
immense. The road, for the most part, will present a series of incli
which the trains will ascend by means of windmills, when there i



by counterbalances on parallel lines of road when there is none, or
The counterbalances will consist of water, stones, gravel, &c. whi
will pump and draw up to a height, when not employed to work th
and tens of thousands of tons of these substances may always
reserve, to be used when there is no wind, as wind *costs nothing;* a
mentioned substances *cost nothing,* and as compressed air, when u
nothing either, locomotion (incredible as this at first sight may ap
reality *cost next to nothing.* The system, however, may of course b
those who would be horror-struck at the idea of getting rid of all
at a tangent, by small steam engines. The platform may be of
and will always have a bearing on six or eight wheels in suc
may weigh two tons, carrying as many passengers as ten railw
accommodate. The carriages, and truck or baggage waggon, w
tons; consequently here will be a diminution of weight of 13 t
A point is thus gained of inappreciable value, but when we add
least, for the weight of the locomotive and tender, we have a saving
of 55 tons in each train; that is, we save the fire necessary
steam enough to waft 55 tons through the air at railway speed
comment upon the advantages here offered to the public would be

We have been induced to notice this invention, solely from the
of its being publicly stated to be under course of trial in Fra
from having the remotest idea of its success.

SECTION V.

TELEGRAPHIC AND SAFETY ARRANGEMENTS.

Prevention of Accidents from Collision.—Curtis's Lamp Signals.—Hawkshaw's Signals and Switches.—Steam Whistle.—Taylor's Guard's Signals.—Porteous's Mouth Whistle.—Electric Telegraph,—principles upon which its action depends.—Cooke and Wheatstone's two arrangements of the Electro-Magnetic Telegraph.—Professor Morse's Apparatus for preventing Collision between Trains.

Prevention of Accidents on Railways from Collision.—The most numerous accidents on railways, and at the same time the (generally) most disastrous in their effects, are those resulting from collision, either between two trains, or between the carriages composing one train, from an accident to the engine or leading carriages; and in the present section we propose to notice some of the means employed to guard against dangers from this cause.

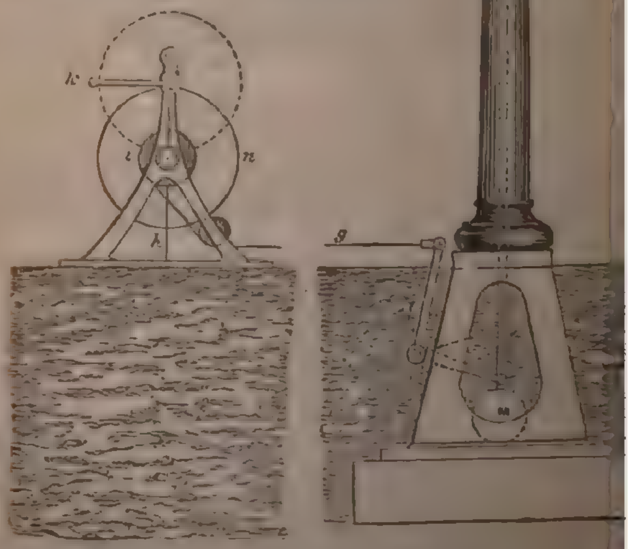
Collisions on railways take place under various circumstances. It may sometimes happen that two trains, proceeding in opposite directions, are at certain parts of the road obliged to travel on the same line of rails, and should they at such time come into collision the results must be the most disastrous. Accidents of this description are however very rare, and unless at sharp curves, or in very foggy weather, could only arise from extreme heedlessness on the part of those employed on both trains. Collisions more frequently arise from a train overtaking another train, proceeding in the same direction, or from a train arriving at a station, which is unexpectedly occupied by another train. In all cases they may be said to arise from some irregularity in the working at some part of the line, and might be avoided if timely notice were given of such irregularity; and accordingly various kinds of signals are employed or have been proposed to effect this, some being produced by sounds, others being addressed to the eye, and in other cases both sound and visible signals being employed.

The figure (page 524) represents Mr. Curtis's apparatus for giving notice of the approach of a train to a station, or warning to a train that the station is occupied. The peculiarity of the plan consists in conveying the signal a mile, or any convenient distance, from the station, with the object that the engineer may pass the signal post, and have distance and time sufficient to stop the train, before reaching the station, or place for stopping. The figure represents the apparatus for exhibiting a light.

"A is a lamp-post surmounted by a lantern of any peculiar shape, with bulls' eyes on three sides, or it may be formed of glass like a street lamp, or in any other manner. C is the lamp with reflectors behind the light in the usual way. D is a shade supported upon the vertical rods *e*, passing through the post and united by a joint at its lower end with the bell-crank F, to which is likewise suspended the ball or weight M. To the other end of the crank F a joint is attached, with which is connected a strong wire *g*, which is led like a bell-wire by proper connexions to the crab *h*, placed in a room of, or near, the station house. The wire, or a chain or rope united to its end, is fastened to the barrel *i* of the crab *h* which coils round the barrel. When a man turns the handle *k*, the barrel is turned round by means of the pinion fixed on the handle shaft, and the barrel wheel denoted by the circle *n*; and the chain or rope or wire is coiled round the barrel, the wire drawn in, and the crank F made to occupy the place shown by the dotted line; and thus the vertical rod *e* and shade D are raised, and the light concealed. The counterbalance M is employed to keep the connecting wire *g* always stretched. In places where gas is employed, a large gas burner may be substituted for the lamp, and the rod *e* made to communicate

with a stop-cock, so that by raising or depressing the rod, the gas may be turned off or on; a small concealed jet of gas may be always burning, so as to inflame the larger jet when the rod is raised by the apparatus: thus a powerful light may be used when needed, and when not required, the gas may not be wasted. The apparatus as drawn is a night signal, or to be used when the weather is so dark that other signals cannot be seen; but for a day signal it is merely necessary to employ a post, so as to raise a vane or vanes like a telegraph, a spar, for example, fixed at the top of the lantern. When it is required to use the telegraph, a man may make the necessary and self-evident connexion between the rod *e* and the limb of the telegraph, which limb being made with a bell crank, when the rod *e* is raised, may cause the telegraph limb to lie horizontally, and when the rod *e* is depressed, it will stand vertically, or the apparatus may be formed double, so as to work both telegraph and lamp at once, whether by day or night

The best arrangement of this system of signals will be, to place them at the same distance asunder as the police are stationed; and instead of making a signal by a flag, upon the passage of a train, they should convey the notice of its approach to the next policeman in advance; which would advise him to look out that switches, points, and everything besides are right.



By a self-evident modification of this apparatus, the engine can be m
communicate its own approach.

allett of Dublin described in the Mechanics' Magazine a lamp of his , which he denominates the *polyzonal* lamp, and of which we extract ring description.

's Polyzonal Lamps.—" Brilliancy and space-penetrating power, in of railway signals, is of the highest importance; and equally, or even are the signals of steam-boats, &c.

e thickness at the centre of the lens of a railway signal lamp depends distance of the lens from the flame of the lamp, in order that the rays may be transmitted parallel; and as this distance is, on account nited size of the lamp, small, so the lens, as usually constructed, is k, generally from 2 to 2½ inches in the centre; and being generally red or some other colour the loss of light by absorption is very great.

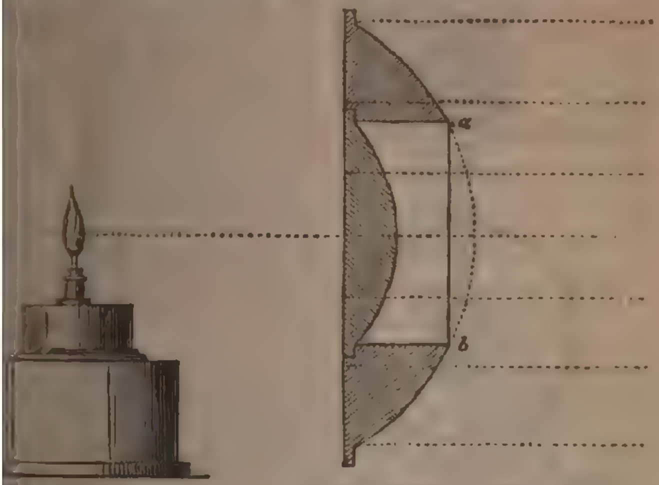


figure represents a mode of obviating this, which I have adopted, by an n of the polyzonal lens of Fresnel. The lens is cast in two parts,—the nnular lens, and the inner or central one, then ground so as to have o focus. The inner lens is fitted to the rebate of the annular one, by anada balsam or other suitable cement; and thus the compound lens, additional expense, has less than half the thickness at the centre of on one, and as short a focal length with much greater penetrative

ht is also saved in the lens, which is of importance in railway signals, unted aloft in stormy weather, and it economises the coloured glass. lenses, to be completely cleaned, must be washed outside to clear out the sharp re-entering corners of the central lens, but even this avoided by fitting and cementing a circular disc of thin plate glass central space, from *a* to *b* in section, to keep out the dust."

haw's Signals and Switches.—In the generality of cases, there is one of the switches, or shunts, which is necessary for the thorough or traffic, and in which direction the trains have to pass at a maximum while the change that is given by the other position of the switches is ently required, and is chiefly passed over by trains at a slow rate. ipal object of Mr. Hawkshaw's invention is, to secure the switches d or kept in a proper position at all times for the principal or thorough

traffic; and when there is occasion to transfer the trains or engine, &c. to another line from that on which the chief traffic passes, it has to be done by some person holding the switch protector in a proper position for that purpose, and immediately after such transfer from one line to the other has been effected, he lets go his hold upon the handle of the apparatus, and it will from its self-acting construction, instantly and of necessity return to its original position, moving at the same time the switches or double rails in connexion therewith in the right direction for the principal or thorough traffic, and maintain them in that position, so as to prevent the possibility of the main lines of rails being left unconnected.

In the subjoined illustration of the invention, *Fig.* 1. is designed to show a front elevation, but with the front plate removed to exhibit the internal mechanism; and *Fig.* 2. is a side elevation at right angles to the former. It

Fig. 1.

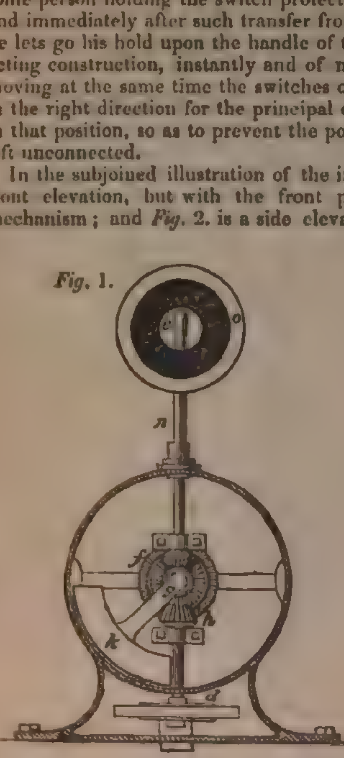
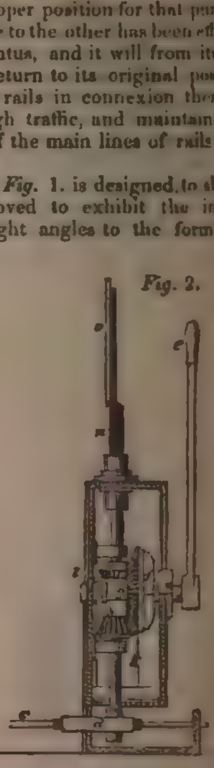
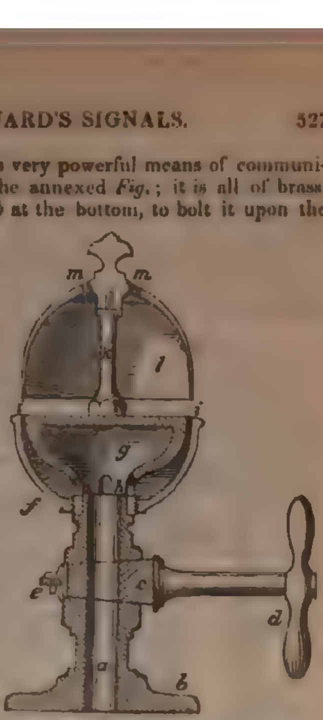


Fig. 2.



will be apparent that by depressing the lever *e* into the horizontal position, the bevelled wheel *f*, on its axis *g*, will actuate two bevelled pinions *h* and *l*, the lower one *h* turning on the vertical spindle *i*, the other end of which carries an eccentric, *d*, that turns the switch or double rail placed in connexion therewith, (but not introduced into the drawing,) in the exact position required for directing a train out of the main into a diverging line: at the same time the upper pinion *l*, through the medium of its vertical spindle *n*, turns a signal disc *o* into the position delineated in *Fig.* 1., which is at right angles with the direction of the main line. The depression of the lever *e* produces a third effect, that of raising a counter balance weight *k*, which is keyed to the axis *g*; so that when the train has passed into the diverging line of rails, the attendant has only to suffer the weight to operate, which brings the lever *e* into the vertical position again, and thereby places the signal disc *o* in its former edgewise position, indicating that the main line is open for the passage of trains. When the continuity of the main line is broken by the position of the switches, the attendant is necessarily there attending it, and the signal also shows to the engine-man of an approaching train that such is the case, in time for the shutting off the steam, and the application of the drags. But as the *reconnecting* of the main line does not depend upon the vigilance of an attendant, but is forcibly self-acting, the risk of accident from the erroneous position of the switch mechanism is reduced almost to an impossibility. To render the signal visible at night, a lamp is placed in the centre of the disc. [London Journal, October, 1839.]

Whistle.—The construction of this very powerful means of communi- ...lligence by sound is shown in the annexed *Fig.*; it is all of brass, ...t *a* is cast hollow with a flanch *b* at the bottom, to bolt it upon the ...t has a cock *c* placed in it with ...*d* and screw *e* to keep it tight; ...e projecting out to allow firm ...taken of it. The cup *f* is fixed ...foot *a* by screwing the piece *g* ...nd both are turned truly at their ...es, leaving a very narrow ...between them all round. The ...hollow, having holes *h* in its ...a pillar *k* stands upon its centre, ...is screwed the bell *l l*; the thin ...hich is brought just over the ...and half an inch above it. ...cock is opened, the steam ...up *f* through the holes *h*, and ...at the narrow slit *i*, striking ...ge of the bell *l*, in a similar ...the action in organ pipes, and ...an exceedingly shrill sound: ...s are made in the top of the ...low the steam to pass freely ...hich improves the sound con- ...The cock is required to be



...ned to adjust the quantity of steam, so as to produce the clearest ...is steam whistle is very effective, and its sound can be heard at a ...nce.

Taylor's Railway Guard's Signals.—Notwithstanding the many plans ...been proposed for the purpose, there is not yet a single invention ...en brought into use for effecting the much wanted communication ...s guards and the engineers.

...lve months ago, Captain Taylor, R. N. submitted to the Admiralty ...nt for giving signals to steamers and other vessels, which he called ...the sounds from which could be heard for a distance of three ...is instrument was a modification of an invention, patented a year or ...ly, by Mr. C. Hood, F. R. S., which was intended to accomplish the ...e proposed, of effecting a communication between the guards and ...on railways, and also for marking by signals the track of steam ...ggy weather. For both these purposes the invention appears to be ...plicable.

...t is accomplished by means of a whistle, similar to that used on ...ve engines, and worked by compressed air instead of steam. Under ...the carriage on which the guard has his seat, is fixed a condensing ...orked by a pinion fixed on the carriage axle. The condensed air ...into a vessel holding about two cubic feet; into this vessel the air is ...il the pressure is about 50 or 60 lbs. on the square inch, when the ...motion of his hand or foot throws the pump out of gear, to be again ...gear by the same means when required. Connected with this ...pe, terminating in a whistle, similar to the high pressure steam ...with all the passages made very much finer and smaller. On the ...these passages much of the efficiency of the instrument depends, ...ng no condensation of steam, as is the case with the steam whistle, ...s out with extreme rapidity, and without any obstruction. This ...laced within a tube in the form of a speaking-trumpet, which is ...ards the engine-man, and by merely turning the handle of the ...werful sound is produced, precisely similar to the steam whistle, ...tensity which can be increased to any amount, by increasing the

pressure of the air in the receiver. The advantage of this plan of signals is, that it does not interfere with any of the other arrangements of the train, and is not dependent on any connexion with other parts of the train for its efficient operation.

The object sought to be obtained by Captain Taylor's proposition may we think be obtained by the improved Mouth Whistle, lately invented by Mr. Porteous, of which the annexed cut is a representation. It consists of a combination of any number of metallic tubular whistles, combined under one mouth-piece, and having their tones so arranged, that by the introduction of one discordant note, an extremely shrill vibrating sound is produced, which is conveyed to a great distance; its peculiar discordance enabling it to be distinguished from any other sound.

Electric Telegraph.—Amongst the numerous inventions to which railways have given rise, or have aided in bringing to maturity, the Electric Telegraph stands pre-eminent, transcending as far all previously known means of transmitting intelligence, as the railway exceeds all previously known methods of transport. The Semaphore or old telegraph, although capable of communicating with considerable celerity under favourable circumstances, might yet be deemed snail-paced in its action when compared with the electric telegraph, and from the lengths of the nights and the state of the atmosphere in this country, it was inefficient for three-fourths of the 24 hours on an average of the year: the electric telegraph, on the contrary, in addition to its action being so rapid as to defy calculation, and therefore being practically speaking *instantaneous*, is by night and by day, and under all circumstances of weather, constantly ready for instant use. Considered in connexion with railways, it affords to the latter advantages at least equivalent to that which it derives from them; for if railways from their security from intrusion afford the most favourable situations for the establishment of these telegraphs, the latter, from the instantaneous notice which they are capable of giving of what is occurring at any point of the line, not only obviate to a great extent the chances of accident, or facilitate the remedy of their effects when they do take place, but in many situations, they render it practicable to employ a single line of rails for a double line, and, by the economy thus effected, are calculated to add greatly to the extension of railways.

The idea of an electric telegraph is not so recent as is generally supposed, but it was not until the discovery of the connexion between electricity and magnetism that it was found reducible to practice, and for this discovery we are indebted to Professor Oersted, of Copenhagen, who first suspecting it in 1806, at length succeeded in proving it in 1819. The facts upon which the action of the electro-magnetic telegraph in its various modifications depends are the following:—

1st. If a magnetic needle be brought near a wire, the ends of which are in contact with the poles of a galvanic battery, the needle will be deflected from its magnetic position, turning to the right or left, according to the course of the electric current.

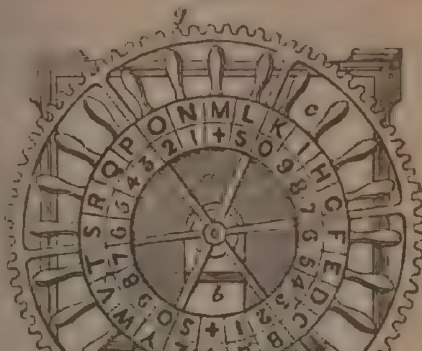
2d. If a wire carrying an electric current be coiled many times round a soft bar of iron, a powerful magnetism is developed in the iron. This magnetism however continues only so long as the electric current continues to pass, the iron becoming instantly demagnetised on the current being interrupted. Thus, if round a bar of iron a long copper wire be wound, (the wire being coated throughout its entire length with some non-conducting substance, in order to

allic contact between the coil,) upon the ends of the wire being n contact the one with the positive, and the other with the le of a galvanic battery, the iron becomes powerfully magnetic, at-h great force any pieces of iron presented to it. On removing the he battery the iron becomes demagnetised, and so rapidly does this and demagnetising process go on, that if the bar of iron be miles n the battery, and the connexion and interruption of the current with the utmost activity, a corresponding electric or non-electric ily appears in the distant iron bar.

l fact (which may be considered as the converse of the second) is, re be moved near a magnet, an electric current is induced by the he wire, and by using a powerful magnet, and large coils of wire, ul electric currents are produced. We shall now proceed to de-modifications of the electric telegraph, based upon the preceding have been, or are at present, in use. We commence with one of phic arrangements, invented by Messrs. Cooke and Wheatstone, n the Great Western railway, between the Paddington terminus ion at Slough.

ngement comprises two distinct parts, namely, the "Communica is stationed at that end of the line from which the message is and the "Indicator," on which the message is read off, which is he opposite end of the line, the two being connected by wires ex-whole distance between the two stations. *Fig.* 1 represents a plan municator.

Fig. 1.



powerful horse-et, supported on wood *b b*, secured en frame *c*. *d d* tensive coils of re, covered with nished. The coils ed on a forked bar n, attached to a s. The axis is inion *f* on its end, es with the large el *g*. The face of s divided into 24 s, one of which ith a cross, to in-rting and finish-nd the remainder sions are each h a letter of the e letters J U and tted. The num-in this wheel is re occurs between as many teeth as th in the pinion, oving the wheel are equal to one or division, the rms one revolu-the electric cur-d in the coils when rotating occurs in only one position, (that is, ked bar of soft iron, upon which they are placed, is in contact with s of the magnets,) and in any other position they are non-electric, ation of the coils a current of electricity through the wires will blished and once broken; and in like manner, in turning the

wheel through the space of ten letters there would be ten electric cu through the wires, and ten interruptions.

We must now proceed to the description of the "Indicator," represent Figures 2 and 3; *Fig.* 2 being an external elevation, and *Fig.* 3 showin apparatus divested of the external casing.

Fig. 2.

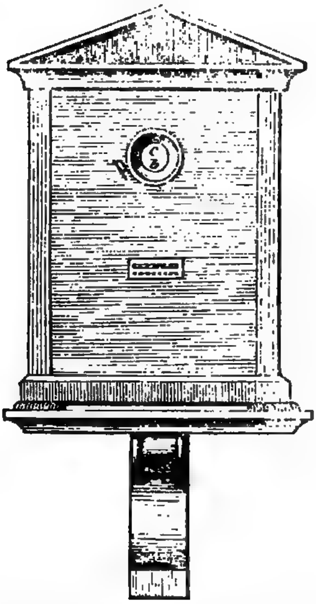
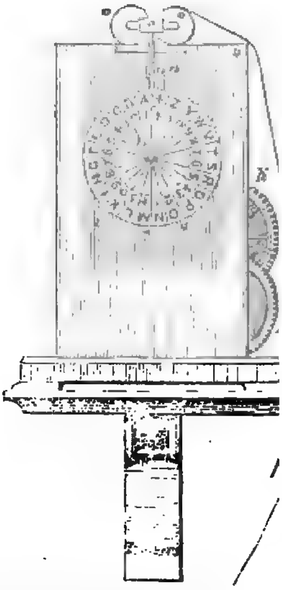


Fig. 3.



This instrument consists, in the first place, of a spring barrel and a t wheels *k*, like a clock train, with a detent or escapement *m*, and having arbor of the last wheel a card *n*, marked with the letters of the alp corresponding with those marked on the face of the communicator. Abo train, and opposite to an iron lever attached to the detent, is fixed a curv of soft iron, round which is wound a coil of covered wire *o*, which is con by the wire *p* with the coils *d d* of the communicator; so that an e current passing through the coils *d d*, passes at the same instant throu coil *o;* the iron bar then becomes instantly a powerful magnet, and attr the lever releases the train, and allows the main arbor, with its card plate, to revolve through the space of one division each time that the c passes through the wire. In the face of the casing which encloses the apparatu an aperture *q*, (as shown in *Fig.* 3,) through which may be seen the upp letter and numeral on the dial card, and this card is so fixed on the arbo when any letter on the communicator is opposite to the pinion, that lett stand uppermost on the dial, and appears through the aperture in the ca

We will now suppose we wish to spell some word at the indicator, and s the communicator in the position shown in the drawing. Opposite the of the communicator is the cross + and opposite to the hole in the in will also be the cross +. Let the word be "art":—if we turn the wheel communicator until the letter *a* is brought opposite the pinion, the co have rotated once, and a current running through the whole length of th the wheel of the indicator will move through a tooth, and expose the le we now turn the wheel until the letter *r* comes opposite the pinion, th

n be made to rotate as many times as there are letters between *a* and *r*, sixteen times, and sixteen currents will have passed through the wires, e wheel of the indicator will have turned through sixteen teeth, and the be exposed. We now want letter *t*, and the letter *r* being opposite ion, we have only to move the toothed wheel through the distance of two to bring *t* to the aperture in the indicator; by thus moving it, two s pass along the wires, and the indicator wheel passes round through ance of two teeth, and the letter *t* is presented. It is obvious that in round the wheel of the communicator so as to bring opposite the pinion nt letter, all the intermediate letters pass the pinion, and by the number ents produced all the intermediate letters have passed before the opening indicator, but they pass so rapidly as not to be distinguishable, and no ill rest opposite the hole but the proper one.

telegraphic arrangement which we have just described, although perhaps st simple in principle, and the most readily comprehensible in its opera- not that which is most generally employed in this country; being deemed, he whole, inferior to that arrangement which is based upon the deflection etic needles by the agency of electric currents, and which we shall now d to describe.

Fig. 1.

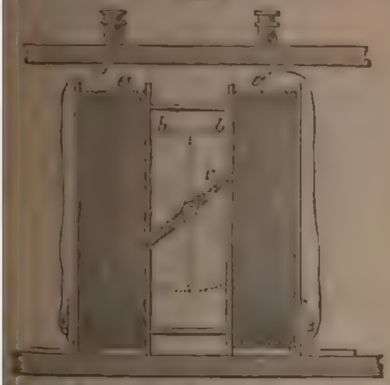
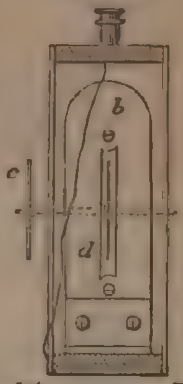


Fig. 2.

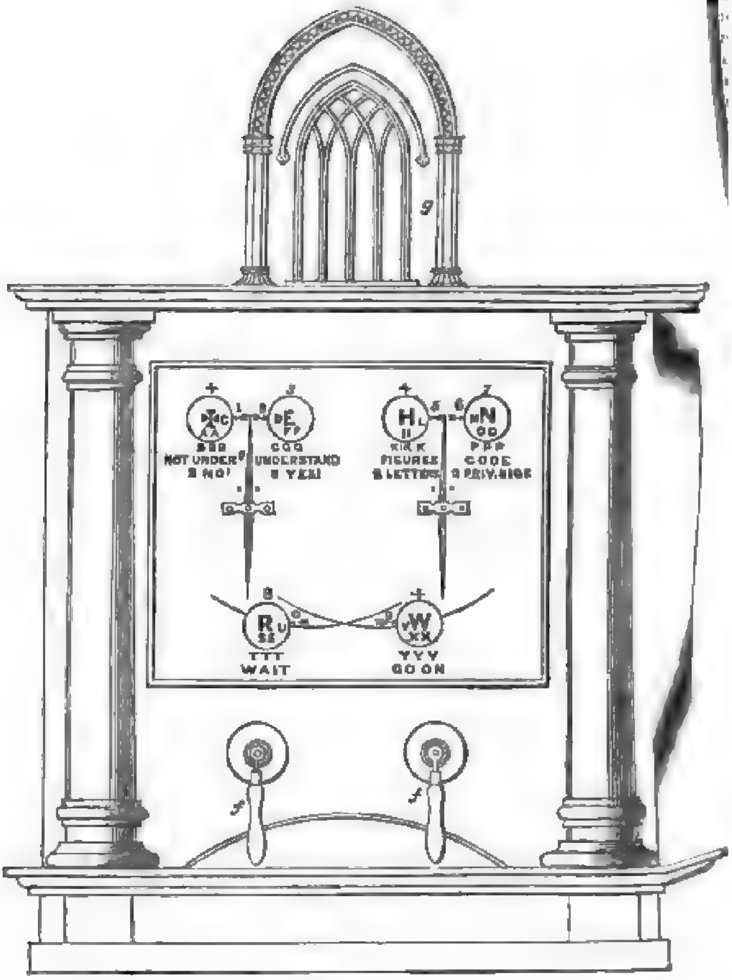


1 and 2 represent the electro-magnetic portion of the apparatus, *Fig.* 1 s front view, and *Fig.* 2 a transverse section. *a á* are two coils of covered ound round a brass frame *b b*, which is bolted to the bottom of the case h the apparatus is concealed; *c c* are two magnetic needles fixed upon *d*, which turns in bearings fixed to the back and front of the case. One eedles is placed upon the middle of the axis between the coils of wire, being formed in the frames *b* to admit of the vibration; the other s fixed upon the end of the axis, which projects beyond the face of the ent. The needles are fixed upon the axis with their respective poles in opposite directions; that is to say, the north pole of the one needle, south pole of the other, points upwards, so as to counteract the effects dip of the needle. Upon passing an electric current through the coils, cting them with a galvanic battery, they immediately exert a deflec- e upon the needles, attracting them to the right or left, according to ne of the electric current, which always flows from the positive to the pole of the battery; thus, if the coil *á* be connected with the positive pole of the battery, the upper end of the needle will point to the right; e coil *a* be connected with the positive pole, the needle will point to In the complete apparatus, two needles or pointers with their separate wire are employed, and the letters of the alphabet, numerals, and a of conventional signals, are indicated by the single or combined move- f the needle on the face of a dial plate fixed in the front of the case in he apparatus is enclosed, and which is shown in *Fig.* 3.

The indications of the various movements of the needles are as follows.

The left hand needle moving once to the left indicates the +, which is given at the end of a word; twice in the same way, A; thrice, B; first right, then left,

Fig. 3.



C; the reverse, D; once direct to the right, E; twice, F; thrice, G; and in the same order with the other needle for H, I, K, L, M, N, O, P.

The signals below the centre of the dial are indicated by the parallel movements of both needles simultaneously. Both needles moving once to the left indicate R; twice, S; thrice, T; first right than left with both, U; the reverse V; both moving once to the right, W; twice, X; thrice, Y.

The figures are indicated in the same way as the letters nearest to which they are respectively placed.

To change from letters to figures, the operator gives H, followed by the + which the recipient returns to signify that he understands.

fter the above signs (H and +), were given, c, a, u, l, were received, ould be understood.

ange from figures to letters is notified by giving I followed by the +, the recipient also returns.

word is acknowledged; if the recipient understands, he gives e, if not , in which case the word is repeated. Stops are placed at z z, to limit ge of the vibrations of the needles. The connexion between the needles battery is made and broken by means of the handles *f f*. Within the is contained an alarum, which is rung to give notice to the person d at the other end of the line, that a communication is about to be This is effected in a similar way to that by which the indicator in the cribed telegraph is set in motion; opposite the lever of the detent is horseshoe bar of soft iron, round which is coiled a quantity of wire, when connected with a wire from a battery, becomes a powerful magnet, tracting the detent lever releases the spring, and thereby sets the alarum on. A similar warning apparatus is attached to the first described ph.

Fig 2

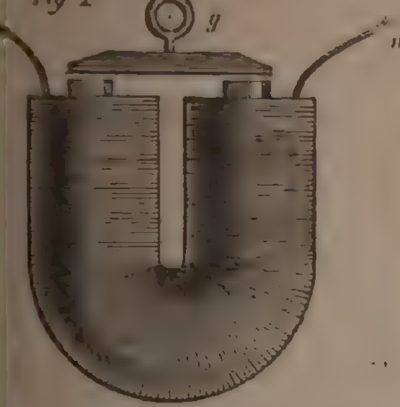
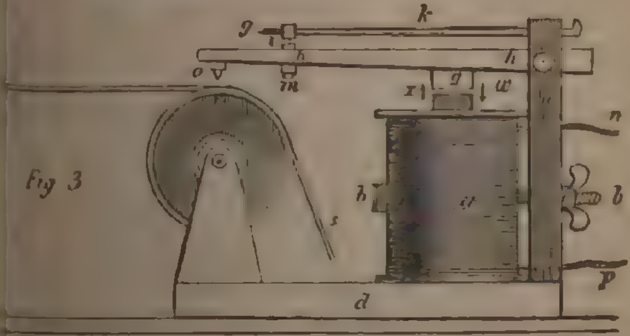


Fig 1

Fig 3



ird arrangement of the electric telegraph is that invented by Professor , and which is the one adopted in America.

electro-magnet is the basis upon which this invention wholly rests in its construction. The electro-magnet is produced by coiling around a bar iron made in the form of a horseshoe (*Fig.* 1.) copper wire previously d, (similar to bonnet wire,) and varnished to prevent metallic contact with

each other and the iron (*Fig.* 2). The two terminations of the wire thus surrounding the iron in a spiral form, are brought out at each end of the curved bar, and are connected one with the zinc pole of a galvanic battery, the other with the platinum pole. The battery being prepared in the usual manner with its corroding acid, produces galvanic electricity, which starts off from one pole of the battery, follows the wire around the soft iron, and returns to the other pole of the battery by the other wire, thus forming a complete circuit. The galvanic fluid is now passing the whole length of the wire, and while thus passing, the curved iron becomes a strong magnet. By connecting the two ends of the bent iron with a bar of similar soft iron, it will support many pounds weight. If while in this condition one of the wires is removed from the battery, the cross bar falls, and with it its weights, and the curved iron returns instantly to its original state. It is unmagnetized. Complete the circuit, as at first, and in an instant it is again a magnet. If the battery is placed 100, or 1000, or 10,000 feet from the iron, yet when the one is connected with the other by intervening wires, the effect upon the magnet is the same, making it a magnet when the circuit is complete, and *vice versâ* when it is broken. In this way power is produced at a point of considerable distance from the generating agent; and it is wholly at the command of the operator at the battery to make or destroy the power produced with the utmost possible rapidity.

The figures on the preceding page represent the most simple form of the electro-magnet, with its appropriate machinery for telegraphic purposes. *a* represents a side view of an iron bar, surrounded with its coils of copper wire, standing upon a platform *d*; *v* being an upright arm secured to *d*, to which the magnet or soft iron is permanently fastened, by means of the bolt *b b* passing between the prongs of the curved iron, and through the board *v*, and the adjusting screw *c*. *e* is the projecting prong of the iron after it has passed through the coils, one only being seen. The other prong is directly behind *e*. *g* represents the end of the iron bar or keeper, extending back so far as to cover both the projecting ends of the horseshoe-formed magnet. The iron bar, or keeper, is fastened to the lever *h h*, which is delicately adjusted so as to rise and fall by a pivot at *i*; *k* represents a steel spring, supported at one end over the lever *h h* by the upright *v*, and passing through a loop *l* formed from a brass wire, the lower part of the brass wire being secured to the lever *h* by means of a screw at *m*. *o* is a hardened steel point, connected with the lever *h h*, and directly over the centre of the metallic roller *t*, in which a slight groove is made to correspond with the point of *o*. *r* represents the standard in which the axis of the roller *t* freely revolves.

The line *s* represents the paper in form of a riband passing from its coil between the roller and the point of *o*; *n* and *p* are the two extremities of the wire upon the magnet *a*.

Every part is now described, and from what has preceded the description, (bearing in mind that the battery, when in action, by forming a complete circuit with the wires *n* and *p*, converts the horseshoe bar into a powerful magnet,) the mode of writing by the instrument may be easily comprehended by what follows.

Complete the circuit, and instantly the cross bar *g* approaches the ends of the magnet *e*, until they meet in the direction of the arrow *w*. Break the circuit, and *g* is carried up in the direction of the arrow *x*, by means of the spring *k*. If to the roller *t* clock work is attached, to give it a uniform movement upon its axis, the paper *s* will move with the same uniform motion under the point *o*, then by completing the circuit the point *o* is brought down upon the paper, which is indented to such a degree as to make it perfectly apparent, and the point continues to mark it in that manner so long as the circuit is closed, but, upon breaking the circuit, the marking ceases, and the point *o* flies from the paper, which continues passing on.

If the circuit is closed and broken with the utmost rapidity, then a succession of dots and of spaces upon the paper appears.

If the circuit is successively closed and broken with less rapidity, short lines and intervening short spaces are made. If closed for a longer time, and broken

-ression, then the marks become longer: so that dots, short lines, long lines, short and long spaces, are made according to the time the circuit is closed, the rapidity with which the paper moves under the pen.

arbitrary arrangement of these dots, short and long spaces, and lines, con-s the telegraphic alphabet, by means of which, intelligence to any extent mmunicated. Thus one dot may represent *a*, two dots *b*, three dots *c*, and a line *d*, &c. The paper to be imprinted, is fixed upon a revolving der, and records despatches day and night; the records of the night may mined in the morning. The alphabet is easily learned.

guard against Collisions.—Figures 5 and 6 represent an apparatus in-d by Mr. Curtis for the prevention of collisions on Railways.

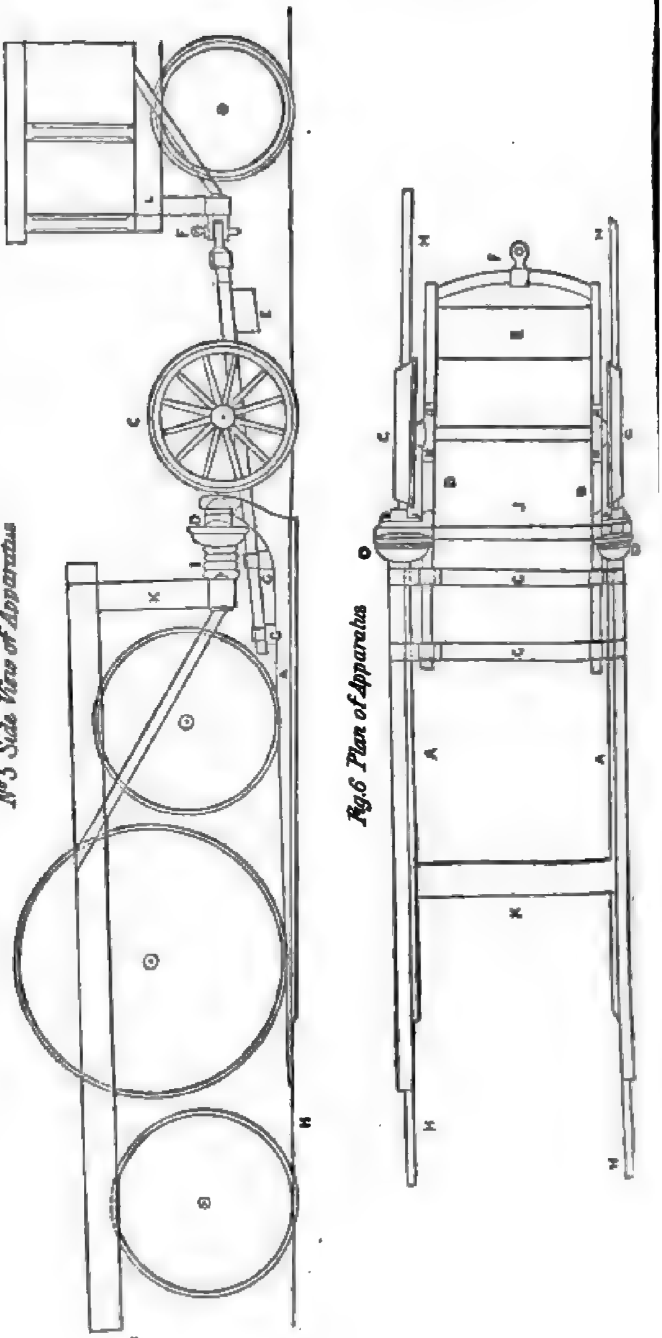
5 is a side view of the apparatus, and an engine in contact with it, hed to the last carriage of a train, and *Fig.* 6 is a plan of the same.

e sledge or retarder A is formed like a wedge, with its superior end turned pon the inner side, flanges are formed, so as to keep it upon the rails; the ides are united together by the cross bar J, the plate K, and the cross o o, and the sides are set to the same gauge as the rails, so that an e may run upon it without difficulty; to the cross bar J, two buffers D D fixed, which correspond with other buffers I, formed upon the front frame engine, so that when the engine comes in contact with the retarder, these receive the concussion; the plate K is used in order to unite the sledge r to the point as possible, and still to allow a free passage to the flanges e wheels. To the cross pieces o o the spring pieces B B are fixed, forming for the wheels C C, upon which the apparatus is carried when out of gear. weight to counterpoise the weight of the sledge, so that a man can move ng the line like a truck with great facility. The coupling F is formed for urpose of connecting the sledge with the train in the usual way, by means joint and pin.

e retarder when out of action, and connected with a train, is attached, e last carriage as shown at L; the sledge then rides above the rails, suspended by the spring pieces B B; but should an accident happen which d stop the train, one of the conductors immediately detaches the retarder, uns back with it, and places it 500 or 600 yards behind the broken down ; then should the engineer of the following train not observe the train be-him, and stop his engine, the engine would run into the retarder, and would e a sledge, and the driving wheels, if not stopped by the great resistance would now be opposed to them, would skid round in the retarder and d have no power to move forwards. No violent concussion would take but the engine would slide along a certain distance in the retarder, when ain would be brought to a stand-still. A hanging frame E must be formed the engine fr me, and the buffers usually placed upon the head board e transferred to the lower frames, or other buffers I be placed there.

the case of a swift train overtaking another train in a fog, or at night, the engine would run into the retarder, and the same effect upon the engine train would be produced as before stated; viz. that it would be brought stand; and the only effect produced to the slow train behind which the der was travelling, would be, that it would be torn away from its fastenings; e purpose therefore of a case of this nature it will be advisable to make the ings such that it may be torn away without the last carriage being subjected y violent shock; with this view the pin at F may be of oak or hard wood, g enough to drag the retarder, but sufficiently weak to give way in the mentioned.

AN APPARATUS TO PREVENT COLLISION BETWEEN TRAINS ON RAILWAYS



No 5 Side View of Apparatus

Fig.6 Plan of Apparatus

SECTION VI.

NOLOGICAL AND DESCRIPTIVE LIST OF ALL PATENTS GRANTED FOR IMPROVEMENTS IN RAILWAYS, AND LOCOMOTION THEREON

down to the 30*th June*, 1846.

Further information respecting these Patents may be obtained at J. Murdoch's British eign Patent Office, 7, Staple Inn, Holborn, London.

March, 1802. R. Trevithick and A. Vivian. For methods of improving onstruction of steam engines, and the application thereof for driving car- and for other purposes.—Described at page 379.

Feb. 1803. J. Woodhouse. For a new method of forming a cast iron plate, which may be used in making iron railroads, or ways for the ing and running of waggons, carts, drays, and other carriages on public other roads, and also a new method of fixing, fastening, and securing such iron rail or plate on such roads.

is formed as hollow quadrangular blocks of cast iron, concave on their surface.—Described further at page 380.

April, 1811. J. Blenkinsop. Certain mechanical means by which the con- ce of coals, minerals, and other articles is facilitated, and the expense ding the same is rendered less than heretofore.—Described at page 382.

Dec. 1812. W. and E. W. Chapman. For a method or methods of facili- the means, and reducing the expense, of carriages, on railways and other —Described at page 384.

May, 1813. W. Brunton. A method and machinery for propelling or ng carriages upon roads or railways.—Described at page 385.

Feb. 1815. R. Dodd and G. Stephenson. For various improvements in onstruction of locomotive engines.—Described at page 386.

Nov. 1815. Jos. Baader. For an improved plan of constructing railroads, carriages to be used on such improved railroads; for the more easy, conve- and expeditious conveyance of all sorts of goods, wares, merchandise, s, and all other articles usually, or at any time, removed in carriages of construction whatever.

Sept. 1816. W. Losh and G. Stephenson. For a method or methods of ting the conveyance of carriages, and all manner of goods and materials railways and frameways, by certain inventions and improvements in the uction of the machine carriages, carriage wheels, railways and frameways oyed for that purpose.

provements in the construction of edge rails and tram plates, and in the of supporting them and connecting them to each other; also in the employ- eam cylinders to support the body of the locomotive, and forming railway s with wrought iron tires and cast iron spokes, or *vice versâ*.—See further 387 and 389.

Aug. 1817. J. Hawks. For a method of making iron rails, to be used construction of railways.

e upper side of the rail is formed of cast iron, and the lower or under side rought iron, which is inserted into the former during the casting.—See r page 391.

Oct. 1820. J. Birkenshaw. Certain improvements in the manufacturing onstruction of a wrought or malleable iron railroad or way.

Making wrought iron rails of a prismatic or wedge form.—See further page 392.

14th Sept. 1821. W. Losh. Certain improvements in the construction of iron rails for railways.

The improvements consist, first, in fixing bars of malleable iron on the upper surface of a line of cast iron rails, or wrought iron rails, so as to form an uninterrupted line the whole length of the bar; Secondly, fixing a strap of wrought iron to the under side of a cast iron rail; Thirdly, uniting two wrought iron ribs or sides to a third plate of wrought iron to form a rail.—See further page 393.

24th Oct. 1821. B. Thompson. Method of facilitating the conveyance of carriages along iron and wood railways, tramways, and other roads.

22d Nov. 1821. H. R. Palmer. Improvements in the construction of railways and tramroads, and of the carriage or carriages to be used thereon.—Described at page 394.

19th Feb. 1824. John Vallance. For producing locomotion by stationary engines.—Described at page 486.

28th Feb. 1824. W. James. Certain improvements in the construction of rail and tramroads, or ways, which rail tramroads or ways are applicable to other useful purposes.

Railways formed of cast iron tubes, having flat tops for the carriage wheels of a train to run upon; the hollow space within being designed for the conveyance of water, to supply water to work machinery by its descent. The patentee also proposed to *impel* the carriages of a train by these conduits, by causing the water to act upon drums.

18th Dec. 1824. W. F. Snowden. For a wheel way and its carriage or carriages, for the conveyance of passengers, merchandize, and other things, along roads, rails, and other ways, either on a level or inclined plane, and applicable to other purposes.—Described at page 396.

5th March, 1825. W. H. James. Improvements on railways and in the construction of carriages to be employed thereon.—Described at page 399.

2d April, 1825. Jacob J. Fisher. New application of railways, and the machinery to be employed thereon.—Described at page 400.

12th April, 1825. R. W. Brandling. Certain improvements in the construction of railroads, and in the construction of carriages to be employed thereon, and elsewhere.—Described at page 401.

10th May, 1825. T. Hill. Certain improvements in the conctruction of railways and tramroads, and in carriages to be used thereon, and on other roads.—Described at page 401.

14th Aug. 1827. Wm. Chapman. Certain improvement, or certain improvements in the construction of waggons that have to travel on railways, or on tramways.

The construction of framework underneath the body of the waggons, to connect the wheels together and allow them more vertical play, and afford a more equal bearing on the four wheels, in those parts of the railroad where the inequality of the level might cause them to bear upon three wheels only.

1st May, 1828. Jon. Brownhill. Improved methods of transferring vessels from a higher to a lower level, or from a lower to a higher level on canals, and also for the more conveniently raising and lowering of weights, carriages, or goods on railroads, and for other purposes.

18th Sept. 1828. W. Losh. Certain improvements in the formation of iron rails for railroads, and of the chains or pedestals, in or upon which the rails may be placed or fixed.—Described at page 413.

21st May, 1829. M. Dick. Improved railroad and method of propelling carriages thereon by machinery, for the purpose of conveying passengers, letters, intelligence, packets and other goods with great velocity.—Described at page 401.

31st Aug. 1830. W. Losh. Improvements in wheels for railway carriages.—Described at page 471.

7th Sept. 1830. C. B. Vignoles, and J. Ericsson. Certain additions to locomotive engines.—Described at page 467.

21st *Feb.* 1831. J. Grime. Certain methods of dissolving snow or ice, on trams or railways, in order that locomotive engines and carriages and other riages may pass over railroads without any obstruction, or impediment, m such snow or ice.—Described at page 445.

11th *March*, 1831. Robert Stephenson. For an improvement in the axles and ts which form the bearings at the centres of wheels for carriages, which are travel upon railways.—Described at page 470.

30th *April*, 1831. George Stephenson. For an improved mode of making eels for locomotive carriages. The improvement consists in the substitution hollow tubes of wrought iron, instead of solid bars, for the spokes of the eels; the application of a preparation of borax, as a flux to the ends of such ular spokes, previously to placing them in the sand mould; and then of uring the cast metal around them to form the fellies and the nave.

5th *Sept.* 1831. George Forrester. For certain improvements in wheels for riages and machinery, which improvements are applicable to other purses.

13th *April* 1832. R. Roberts. Certain improvement, or certain improvements steam engines, and also in the mechanism through which the elastic force steam is made to give impulse to, and regulate, the speed of locomotive riages.

29th *June*, 1832. J. Macdonald. Improvements in the construction of ways.

15th *Sept.* 1832. R. Badnall. Improvements in the construction of the trams rails or lines of tramroads, upon which locomotive engines shall or may worked.—Described at page 513.

8th *Nov.* 1832. H. Scrivener. For certain improvements in the construction iron railways.—Described at page 417.

20th *Dec.* 1832. Jos. Saxton. Certain improvements in propelling carriages, d in propelling vessels for inland navigation.—Described at page 510.

26th *Jan.* 1833. R. Stephenson. Certain improvements in the locomotive am engine, now in use for the quick conveyance of goods and passengers on edge railroads.

1st *June*, 1833. Wm. Jessop. Certain improvements in the construction of ways.—Described at page 414.

10th *June*, 1833. R. Smith and J. Walkinshaw. Improved rail for railroads.

29th *June*, 1833. Jos. Gibbs and A. Applegath. Improvements in the construction of railroads, bridges, piers, jetties, and aqueducts, part of which may applied to other useful purposes.

7th *Oct.* 1833. R. Stephenson. Certain improvements in the locomotive am engine now in use for the quick conveyance of passengers and goods on edge railroads.

Forming driving wheels (of six wheeled locomotives) with plain tires, *i. e.* hout flanges, and a peculiarly constructed brake, set in action by a small am engine.—See further page 449.

11th *Dec.* 1833. R. Stephenson. Improvements in the mode of supporting e iron rails for edge railroads.—Described at page 415.

1st *March*, 1834. H. Pinkus. Improved method of, or apparatus for, communicating and transmitting, or extending motive power, by means whereof riages or waggons may be propelled on railways, or common roads, and ls may be propelled on canals.—Described at page 487.

9th *Oct.* 1834. B. Hick. Certain improvements in the locomotive steam riages, parts of which improvements are applicable to ordinary carriages d to steam engines employed for other uses.—Described at page 483.

20th *Nov.* 1834. R. Whiteside. Certain improvements in the wheels of steam riages, and in the machinery for propelling the same, also applicable to er purposes.

2d *Jan.* 1835. J. Day. Improvement or improvements in the construction of railways.

5th *Feb.* 1835. J. Price. Certain improvements in railways, and in the ans of transporting carriages from one level to another.

4th March, 1835. T. F. Bergin. Improvements in railway carriages, which improvements are applicable to other purposes.—Described at page 475.

5th May, 1835. J. Reynolds. Certain improvements in railways.—Described at page 419.

10th Aug. 1835. S. W. Nicholl. Certain improvements in rendering steam engines portable, and applicable as a means of general transport on rail and other roads.

17th Aug. 1835. H. Pinkus. Improvements in inland transit, which improvements are applicable to and may be combined with an improved method of, or combination of methods and apparatus for communicating and transmitting or extending motive power, by means whereof carriages or waggons may be propelled on railways or roads, and vessels may be propelled on canals. —Described at page 487.

3d Dec. 1835. T. Parkin. Improvements in sleepers or bearers applicable to railways.—Described at page 420.

16th Dec. 1835. H. Booth. Improved method of attaching railway carriages together, for the purpose of obtaining steadiness and smoothness of motion.—Described at page 482.

23d Jan. 1836. H. Booth. Improvements applicable to locomotive steam engines, and railway carriages.

23d April, 1836. G. A. Kollman. Improvements in railways, and in locomotive carriages.—Described at page 468.

23d April, 1836. E. J. Massey. Improvements in railway and other locomotive carriages.

17th May, 1836. H. W. Wood. Certain improvements in certain locomotive apparatus.

18th May, 1836. P. B. G. Debac. Improvements in railways.

6th Aug. 1836. T. Binns. Improvements in railways, and in the steam engines to be used thereon, and for other purposes.

4th Oct. 1836. J. White. Certain improvements on railways.

13th Oct. 1836. J. Ruthven. Improvements in the formation of rails or rods for making railways, and in the method of fixing or joining them.

8th Nov. 1836. J. E. Smith. Improvements in railways, and in locomotive carriages to work on such railways.

3d Dec. 1836. H. Booth. Improvements in the construction and arrangement of railway tunnels, to be worked by locomotive engines.

9th Dec. 1836. J. Yates. Improvements in tramroads or railroads, and in the wheels, or other parts of carriages to be worked thereon.

15th Dec. 1836. J. Melling. Certain improvements in locomotive steam engines to be used upon railways or other roads, part or parts of which improvements are also applicable to stationary steam engines, and to machinery in general.

25th April, 1837. J. Pim, and T. F. Bergin. For an improved means or method of propulsion on railways.

Certain peculiar arrangements for applying manumotive power to propelling carriages on railways.

4th April, 1837. H. Booth. Improvements in the construction of locomotive engines, boilers, and furnaces, also to other furnaces.

13th May, 1837. P. B. G. Debac. Improvements applicable to railroads.

26th July, 1837. J. Melling. Improvements in locomotive steam engines, to be used upon railways, parts of which improvements are applicable to stationary steam engines, and to machinery in general.—Described at page 425.

25th Nov. 1837. H. P. Vaile. Improvements in rails for railroads.

19th Dec. 1837. E. B. Rowley. Certain improvements applicable to locomotive engines, tenders, and carriages, to be used upon railroads, and which improvements are also applicable to other useful purposes.

4th Jan. 1838. N. Worsdell. Improvements in apparatus to facilitate the conveyance of mail bags, and other parcels on railways or roads.

Apparatus for receiving and delivering railway bags and parcels, along a line of railway, at places intermediate between the stations, without stopping

The bags to be delivered are suspended by their loop from two bar projecting from the carriage, from which bar also projects a hook, and the bags to be received from the post house are suspended milar apparatus, attached to a lamp post. By passage of the carriage lamp post, the hook on the latter passes through the loop of the bags, and bears them off the pins, and the hook on the carriage in like carries off the post house bags.

1838. J. Deville. Certain improvements in railroads, and in the to be used thereon.

March, 1838. T. Evans. Improved rail for railway purposes, together mode of manufacturing and fastening down the same.

1838. J. White. Certain improvements in the construction of bridges, and viaducts.

Aug. 1838. E. de Beuret. Certain improvements in the construction of and tramroads, to facilitate the ascent and descent of hills and inclined

Aug. 1838. C. Fox. Improved arrangement of rails for the purpose of railroad engine, carriage, or train, to pass from one rail to another.

Aug. 1838. J. C. Hadden. Certain improvements in the construction to be used on railways, and in the method of forming the same

Aug. 1838. J. Curtis. Certain improved machinery and apparatus, for of travelling, and transport on railways, parts of which are applicable purposes.—Described at page 428.

Sept. 1838. T. Wilkinson. Certain improvements in the construction railways, and in the carriages to be used thereon.

1838. J. Deville. Improvements in railroads, and in carriages

Dec. 1838. J. Hawkshaw. Certain improvements in mechanism, or applicable to railways, and also to carriages to be used thereon.— at page 525.

1839. T. Harper. Certain improvements in railways or tram-

Aug. 1839. G. A. Kollman. Improvements in railways, and in loco- other carriages. Described at page 468

1839. J. Faram. Certain improvements in the mode of constructing, and using railway switches, for connecting different lines of railway, railways, and for passing locomotive steam and other engines, carriages and waggons, from the one to the other of such railways, certain apparatus connected therewith.

1839. C. Nickels. Improvements in propelling carriages.

1839. J. Nasmyth. Certain improvements applicable to railway

ing the momentum of the train to bring the train to rest by connecting or stems of the buffers, to the brake levers, which are brought down buffers being forced in.

1840. J. Rangeley. Improvements in the construction of railways, means of applying power to propel carriages, and machinery.

May, 1840. H. Dircks. Certain improvements in the construction of steam engines, and in wheels to be used on rail and other ways, which improvements are applicable to steam engines generally.

consumption of smoke in locomotives where coal is used for fuel.

ing wheels of iron with a channel in the periphery, filled up with wood placed with the grain standing radially.—See further page 473.

May, 1840. D. Gooch. Certain improvements in wheels and loco- engines to be used on railways.

May, 1840. W. H. Smith. Improvement or improvements in the resisting shocks to railway carriages and trains, and also in the mode ing and disconnecting railway carriages; also in the application of carriages.

30th May, 1840. W. Pettit. For a communicating apparatus, to be applied to railroad carriages.

9th June, 1840. J. G. Shuttleworth. Certain improvements in railway and other propulsion. A mode of propelling by hydraulic pressure.

7th Aug. 1840. A. Smith. Certain improvements in carriages, rails, and chairs for railways.

The tires of the wheels are formed with a rectangular groove on the periphery instead of a flange on the side. The rails are square bars of iron, let into grooves cut in wooden sleepers, with one of the angles upwards, and the chairs clip the sides of the rails in a dove-tail form.

10th Sept. 1840. Henry Houldsworth. Improvements in carriages, and for the conveyance of passengers on railways, and an improved seat applicable to such carriages and other purposes.

Application of wire gauze to carriages, to exclude dust, &c, and to break the violence of the current of air in rapid travelling, without materially obstructing the view of external objects, also seats which fold up of themselves when not in use.

22d Sept. 1840. T. Paine. For a plan by means of which carriages may be propelled by atmospheric pressure, only without the assistance of any other power, being an improvement on the atmospheric railways now in use.

15th Oct. 1840. R. Pettit. Improvements in railroads, and in the carriage and wheels used thereon.

1. Forming the wheels without flanges, and retaining them on the rails by means of horizontal wheels pressing against the inner side of the bearing rail or against a centre rail.

2. An improved brake to be worked by hand.

3. A self-acting apparatus to be attached to railway engines, which shall cut off the steam, sound the alarm, and bring down the brake.

2d Nov. 1840. E. Galloway. Improvements in propelling railroad carriages.

2d Nov. 1840. J. Boydell. Improvements in working railways and other carriages, in order to stop them, and also to prevent them running off the lines or rails.

A brake lined with wood clips the rail, to stop the carriages, and bars extended below the carriages from opposite corners, to retain the carriages on the rail.

12th Nov. 1840. E. Birch. Improvements applicable to railroads, and to the engine and carriages to be worked thereon.

Self-acting brake, whistle, and signal apparatus.

21th Nov. 1840. F. Pope. Improvements in detaching locomotive and other carriages.

The shafts in common carriages, and the drag link in locomotives, are connected to a tongue held down by a spring catch, to which a lever is affixed. on pulling the lever, the catch is disengaged, the tongue flies over, and the horse or locomotive is released.

24th Nov. 1840. J. Haughton. Improvements in the means employed in preventing railway accidents, resulting from one train overtaking another.

A mode of employing a time-keeper, suitably acted upon by each passing train, to show the time which has expired between the passing of one train and the coming up of another, and also to register the time of each train passing.

16th Dec. 1840. J. Beathie. Certain improvements in locomotive engines and in chairs and wheels for use upon railways, and certain machinery for use in the construction of parts of such inventions.

Apparatus for increasing the adhesion; improved buffing apparatus; brake with whistle attached, and coupling chain; improved railway chair; elastic wheels for railway carriages.

18th Dec. 1840. A. A. Lindo. Improvements to be applied to railways and carriages thereon, to prevent accidents, and to lessen the injurious effects of accidents to passengers, goods, and railway trains.

A self-acting whistle and governor; an apparatus for clearing the rails of obstructions, another for lifting men or animals off the rails; an apparatus to

carriages running off the rails, and to support them in the event of a breaking; an improved buffer, and an improved mode of transmitting

Dec. 1840. E. R. Handcock. Certain improvements in mechanism to turn-tables for changing the position of carriages upon railroads, fure, and other purposes.

turn-table is supported on a vertical spindle, round the upper and lower which are placed two loose collars, or anti-friction rollers, to diminish thrust of the socket, which is attached to the under side of the table. other page 433.

Dec. 1840. G. Thornton. Certain improvements applicable to railways, engines, and carriages.

improvements are: a medium gauge of about 6 feet; a self-acting steam and water governor; preparatory heating of water in a case surround-smoke box; turning the waste steam into the chimney; cleaning out the by a jet of steam and hot water; a self-acting brake for the wheels of , and brakes to the carriages, which are raised by a drag rope from , and descend upon the rope becoming slack.

1840. H. M. Grover. Improved method of retarding and stopping carriages, and trains.

Sept. 1840. Henry Pinkus. Improvements in the methods of applying power to the impelling of machinery, applicable amongst other things ling carriages on railways, on common roads or ways, and through vessels afloat, and in the method of constructing the roads or ways carriages may be impelled or propelled.

ling by exploding gas, by electricity, and by what the patentee terms pneumatic power.

1841. Henry Bessemer. New mode of checking the speed of, or railway carriages under certain circumstances.

acting brake, which is brought into immediate action upon any dimi-the regulated distance between the locomotive engine and the train , by the operation of compressed air.

. 1841. W. Hancock. Certain improved means of preventing on railways.

set in action by the pressure of steam in the boiler, self-acting and a mode o signalizing accidents, and the exact time of their

. 1841. R. B. Curtis. Method or methods of making signals by apparatus, to be used on railways, for the purpose of obviating between successive trains.

er upon a signal post is raised, and maintained at a certain height by wheels, actuated by a weight, which is wound up once in 24 hours. in passing detaches the pointer from the wheel work, and the cends to the lowest point, but when the train is past, the wheel work ly elevates the pointer, and by the position of the pointer, the driver ceeding train can judge how far the preceding train is ahead of him.

. 1841. W. Gall. Certain improvements in the construction of engines, and of the carriages used on railways, applicable in part to sed on common roads.

. 1841. W. C. Harrison. Improved turning table for railway

ngement of anti-friction rollers round the central post which supports

1841. W. W. Taylor. Improvements in buffing apparatus for rail-

a series of layers of felt to the ordinary buffer head, or to a ding across the whole breadth of the end of the carriage frame, and felt with leather or other water-proof material.

1841. J. Bunnett. Certain improvements in locomotive engines and

An improved steam regulator, five different sorts of brakes, and an axle-guard, which allows a compensating movement when the wheels are traversing curves.

8th Feb. 1841. E. Oldham. Certain improvements in the construction of turning tables, to be used on railways.

The table or platform is supported on a pivot at its centre, and assisted by stationary anti-friction rollers at the circumference.

8th Feb. 1841. J. Scott. Improvements in constructing railways, and in propelling carriages thereon, which improvements are applicable to raising and lowering weights.

A series of cog wheels placed at short intervals along the centre of the railway, and driven by stationary engines, give motion to the carriages by means of a rack attached to the under side of the carriages.

15th Feb. 1841. J. Ransom and C. May. Improvements in the manufacture of railway chains, railway or other pins or bolts, and in wood fastenings and handrails.

Casting railway chairs by means of metal side plates and metal cores in sand moulds. Forming wooden pins and wedges, by forcing them into metal moulds, and heating them whilst under compression, till the elasticity of the wood is sufficiently overcome. See further at page 421.

22d March, 1841. Thomas Wright. Certain improvements applicable to railway and other carriages.

Improvements in brakes, axle-trees and boxes, carriage springs, safety flanges on the outer edge of the ordinary flange on railway wheels, hollow steel spokes, and an elastic plate to serve as a brake, a sledge and a buffer.

17th April, 1841. P. Kendall. Improved method or methods of connecting and disconnecting locomotive engines and railway carriages.

The connecting link from the tender is received between two elastic metal plates, and a stud projecting from each side of the link, passes through holes in the ends of the plates, and so long as the pull is in a direct line, the link is firmly retained by the plates, but if the strain should become oblique to the elastic plates, the link is released.

11th May, 1841. E. Taylor. Certain improvements in the construction of carriages used on railroads.

Constructing the roofs and pannels of railway carriages of papier mâché, affixing to one wheel a solid axle, which revolves in a hollow axle affixed to the opposite wheel, and forming wheels with segments of wood or of papier mâché within the tire.

20th May, 1841. John Carr. Improvements in apparatus for retarding and stopping railway carriages.

Brakes moved by a screw acting upon an arrangement of levers.

22d May, 1841. Joseph Woods. Certain improvements in locomotive engines, and also for certain improvements in the machinery for the production of rotatory motion for obtaining mechanical power, which improvements in machinery are also applicable for raising or impelling fluids.

Employing loose wheels on locomotives, in order to traverse curves more easily; improved lubricator; improved reversing gear; connecting a whistle to the blast pipe to give a constant intermittent whistle in a fog; improved swivel joints to the water pipe of the tender, and a rotatory disc engine.

5th June, 1841. J. Gibbs. Improvements in roads and in railways, and in the means of propelling carriages thereon.

A mode of propelling railway carriages by fixed engines.

23d June, 1841. R. Stephenson. Certain improvements in the arrangement and combination of the parts of steam engines, of the sort commonly called locomotive engines.

1. Lengthening the cylindrical portion of the boiler, so as to admit the three axles of six-wheeled engines to be placed beneath the cylindrical part of the boiler, and between the front of the fire-box and the back of the smoke-box.

2. Improvements in the slide valve and reversing the gear; and

2. Working the feed pumps by means of the eccentrics which are employed to cause the engine to run backwards along the rails.

9th July, 1841. A. B. Von Rathen. New method or methods, called by the inventor "The united stationary and locomotive system," of propelling locomotive carriages on railways and common roads, and vessels on rivers and canals, by the application of a power produced or obtained by means of machinery and apparatus unconnected with the carriages and vessels to be propelled.

4th Dec. 1841. J. Edwards. Improvements in giving signal on railways.

1. The using of a series of lamps for night signals, and by the different combinations of the lamps when exposed, or when closed, to communicate from a train of carriages to a station, or from a station to a train, or from one train to another.

2. The giving signals by day, by combining the use of a series of thin plates, presenting some edgeways and others flatways, and in combining in various ways.

16th Dec. 1841. C. E. Austin. Apparatus for what is commonly called changing the line of railways.

18th Dec. 1841. W. Prowett. Improvements in giving signals on railways. A mode of communicating by signals to a passing train, of the time since the previous train passed; the apparatus by which this information is given being set in motion by each successive train as it passes by it, thus avoiding the probability of one train running into the preceding one, at night, or in foggy weather.

31st Dec. 1841. T. Wright and A. Bain. Improvements in applying electricity to control railway engines and carriages, to mark time, to give signals, and print intelligence, at distant places.

26th Feb. 1842. T. R. Crampton and J. C. Hadden. Improvements in engines and railway carriages.

9th April, 1842. J. G. S. Clarke. Improvements in supplying and regulating air to the furnaces of locomotive engines.

3rd May, 1842. John Bishop. Improved construction of brake apparatus, applicable to railway carriages.

1st June, 1842. John Dickinson. Improvements in rotatory engines and means in stopping railway carriages, and in machinery for propelling vessels, part of which improvements are applicable to propelling air and gases.

16th July, 1842. R. Benton. Certain improvements in propelling, retarding, and stopping carriages on railroads.

4th Aug. 1842. John Lee. Improvements in wheels and axletrees, to be used on railways and in machinery, for stopping on, or preventing such carriages from running off railways, which improvements may also be applied to other carriages and machinery.

31st Aug. 1842. C. F. Giutard. Certain improvements in the construction of railways.

24th Sept. 1842. W. H. James. Certain improvements in railways, and in other ways, railway and other carriages, and in the mode of propelling the said carriages, parts of which improvements are applicable to the reduction of friction in other machines.

25th Nov. 1842. P. T. Ralli. Improvements in the construction of railway and other carriages, and in apparatus connected therewith.

1st Dec. 1842. C. H. Wild. Improved switch for railway purposes. Causing the moveable rails to move through certain different degrees of space (although worked by one lever), so as to be perfectly in gauge, when opened for diverging trains, and quite safe.

1st Dec. 1842. James Morris. Improvements in locomotive and other steam engines.

Expansive slide valve.

8th Dec. 1842. Baron V. de Wydriff. Improvements in the construction of railways, and in wheels to run on railways, and in apparatus for clearing rails.

10th Jan. 1843. C. Bailey. Certain improved constructions of rails for tramways and railways.

12th Jan. 1843. F. M. Gietrick and M. B. Tennant. Improvement in appara-

tus for preventing the engines and carriages from going off the line of rail and for removing obstructions on railways.

21st Feb. 1843. L. H. Potts. Improved method or methods of con goods, passengers, or intelligence.

7th April, 1843. R. and W. Hawthorne. Certain improvements in locom engines, part of which are applicable to other steam engines.

Improved apparatus, denominated "an auxiliary expansion slide fram working locomotive engines expansively

20th April, 1843. J. G. Bodmer. Certain improvements in locomotive e and carriages, to be used upon railways, in marine engines and vessels, the apparatus for propelling the same, and also in stationary engines, apparatus connected therewith, for pumping water, raising bodies, blowing or exhausting air.

22d June, 1843. L. la Paige. Certain improved method or metho preventing accidents on railways.

22d June, 1843. Samuel Ellis. Improvements in weighing machines, turn-tables to be used on, or in connexion with, railways, and in we machines, to be used in other situations.

17th Aug. 1843. F. Lipscombe. For an hydrostatic engine, parts where applicable as improvements to other engines, and other purposes, and improvements in railway carriages.—Described at page 472.

8th Feb. 1844. W. Newton. Improvements in propelling on railw Described at page 507

24th Feb. 1844. John Aitken. Improvements in atmospheric railways.

Producing a vacuum in the traction pipe, by filling it with water, and car off such water by eduction pipes descending about 35 feet below the tr pipes, with their ends immersed in water also; in rendering the longit valve of the traction pipe air tight, by keeping it covered with water.

6th March, 1844. W. H. Barlow. Improvements in the construction of wedges, and fastenings for engineering purposes.

The keys are of metal and are made hollow, as affording elasticity, ligh and strength.

19th March, 1844. H. Inglis. Improvements upon locomotive steam en whereby a saving of fuel will be effected, which improvements are appl to steam vessels, and other purposes, and to the increasing the adhesion wheels of railway engines, carriages, and tenders upon the lines of railwa

30th April, 1844. J. Samuda, and J. A. Samuda. Certain improvemen the manufacturing, and arrangement of parts and apparatus, for the constr and working of atmospheric railways.

30th April, 1844. John Melville. Improvements in the constructio modes of working railways.

17th May, 1844. J. Pilbrow. Certain improvements in the machinery fo new method of propelling carriages on railways and common roads, and on rivers and canals.—Described at page 503.

29th Aug. 1844. W. Newton, Improvements in the means of prev shocks, or accidents, on railways, or in lessening the dangerous effects therefrom.

22d Oct. 1844. J. Nasmyth and C. May. Improvements in working pheric railways, and in machinery for constructing the apparatus em therein.

9th Nov. 1844. W. Prosser. Improvements in the construction of road in carriages to run thereon.—Described at page 469.

The atmospheric main is connected with two cylindrical vessels, vertically, and which communicate alternately, with a steam boiler, and condenser, in which a jet of water is maintained; whereby a vacu produced in each cylinder in succession, (as in Savery's steam engine,) air rushing from the atmospheric main into the cylinders; becomes until the vacuum in the main is equal to that in the cylinders.

Another improvement consists in forcing down the brakes by pne pressure.

4th Nov. 1844. J. Farrell. Certain improvements in machinery, whereby carriages may be impelled on railways, and tramways, by means of stationary engines or other power, including certain apparatus connected with the carriages run on same.—Described at page 516.

18th Dec. 1844. W. Prosser. and J. Baptiste. Improvements in working atmospheric railways.

16th Jan. 1845. H. A. Dubern. Improvements in atmospheric railways.

18th Jan. 1845. H. Lacey and G. W. Buck. New method for manufacture and method for sustaining, the rails of railways.

Application of wrought iron to sustain the rails of railways, in lieu of the wooden sleepers, or of the stone blocks at present employed.

10th Feb. 1845. R. B. Longridge. Improved locomotive engine.

10th Feb. 1845. F. H. Maberly. Certain improvements in machinery, or the apparatus for stopping or retarding railway or other carriages, applicable also to these purposes in regard to other engines or wheels.

13th March, 1845. Thomas Dunn. Certain improvements in, or applicable to turn-tables, to be used on or in connexion with railways.

7th April, 1845. E. Bury. Certain improvements in locomotive engines, carriages, or waggons running upon railways, or common roads, for the prevention of accidents.

10th April, 1845. E. Galloway. Improvements in propelling railway carriages.

Modification of Saxton's differential pullies, with a view to prevent the slipping of the rope—employment of wire rope, and an improved mode of attaching the drag carriage.

14th April, 1845 J. C. Hadden. Improvement in preparing sleepers, chairs, and spikes, and constructing wheels for railways.

10th May, 1845. W. Prosser and J. Brett. Improvements in railways, and in propelling railway carriages.

10th May, 1845. J. M. Chapman. Improvements in the manufacture of rails and other parts of railways.

17th May, 1845. A. Mac Dougall. Improvements in the method of working atmospheric railways.

4th June, 1845. Palmer. Improvements in working atmospheric railways, and in lubricating railway and other machinery.

23d June, 1845. Thomas Clarke, and John Varley. Improvement on the atmospheric system of propulsion, which is also applicable to other motive purposes

23d June, 1845. R. Griffiths, H. G. Bovill, and G. Hennet. Improvements in the construction of parts of apparatus used for propelling carriages and vessels by the atmosphere; and improvements in propelling carriages and vessels by atmospheric pressure.

25th June, 1845. J Zambaux. improvements in atmospheric railways.

25th June, 1845. W. S. Ward. Improvements in exhausting air from tubes or vessels, for the purpose of working atmospheric railways.

3d July, 1845. John Hopkins. Certain improvements on rails, and trains for railroads, and tramways.

3d July, 1845. F. Walker and G. Mills. Certain improvements in springs and elastic power, as applicable to railway carriages and other vehicles, and to other articles and purposes in which springs, or elastic power, are now used.

Employment of air confined in bags to serve as springs to carriages, and employing ammoniacal gas as a motive power.

3d July, 1845. W. Newton. Certain improvements in railways, and in the means of propelling carriages.—Described at page 507.

5th July, 1845. Jacob Brett. Improvements in propelling carriages on railways and other roads and ways.

A hollow flat rail placed edgeways, extends the whole length of the line between the rails for the carriage wheels, and communicates by branch pipes at suitable distances with the pneumatic main, in which the air is highly compressed by means of air pumps, worked by stationary engines. The flat rail is

enveloped in an air-tight bag, and the compressed air in the rail distending the bag, causes it to press upon two rollers attached to the leading carriage, and thus impels the train.—See Keene and Nickel's invention, page 505.

A second improvement consists of a suspension railway worked by the same means.

12*th July*, 1845. J. S. Templeton. Impelling carriages on railways. A modification of one of Mr. Pinkus's plans, in which locomotive engines are worked by communication with a pneumatic main, in which the air is either rarefied or highly compressed by means of air pumps worked by stationary engines.

12*th July*, 1845. J. Malcomson. Improvements in apparatus used for propelling carriages on roads, and vessels on inland waters, when employing atmospheric pressure.

A close tube is laid along a line of railway, and a vacuum is maintained in it throughout its entire length, by the simultaneous action of all the stationary engines fixed along the line: the close tube communicates with the several sections of the valved atmospheric main, by means of branch pipes, furnished with valves, by opening which in succession a vacuum is created in advance of the piston, as it enters the different sections of the main.

21*st July*, 1845. J. Brett. Imp ovements in atmospheric prop ulsion, and in the manufacture of tubes for atmospheric railways and other purposes.

A series of hollow pistons, communicating with a pneumatic main, are placed midway between the rails at stated distances throughout the line, and attached to the train is a tube (named the locomotive tube), having on the under side a slit running the whole length of the tube, and at each end of the tube is a hinged valve. In the passage of the train, the tube receives within it the fixed pistons in succession, and the compressed air rushing through the pistons and impinging on the hanging valve at the end of the tube impels the train.

29*th July*, 1845. G. Beadon. Improvements in propelling vessels and land carriages in raising and drawing off water for driving machinery, which means of raising and drawing off water are applicable to other useful purposes.

Improvements in screw propellors, and applying a combination of oblique and direct propulsion to carriages, also a new pump and a mode of increasing the adhesion of bands to driving wheels.

30*th July*, 1845. E. Coleman. Improvements applicable to the moving of locomotive engines on inclined planes of railway.

Ascending inclines by means of an archimedean screw, attached to the locomotive, and working into a line of rollers, laid down midway between the rails. The screw is driven by bevelled geer, fixed on the shaft of the driving wheels, and on the axis of the screw.

31*st July*, 1845. J. Quick and H. Austin. Improvements in the construction and working of atmospheric railways.

1. Forming the tubes composing the atmospheric main of two or more longitudinal pieces, connected together by elastic joints, so as to allow the pipe to expand for the passage of the piston arm, and to close afterwards by the pressure of the atmosphere.

2. Working lines with numerous intermediate stations (as the Blackwall railway) by means of a close tube in which a vacuum is constantly maintained by the engines, and which communicates with the atmospheric mains by branch pipes fitted with valves.

3. An arrangement for making a smaller number of fixed engines suffice.

4. An expanding piston to suit enlargements of main, where greater power is required.

7*th Aug*. 1845. H. Smith. Improvements in the manufacture of wheels for railways, and in springs for railways and other carriages, and in axle-guards for railway carriages.

The principle of these improvements consists in a method of welding, forming, and fixing the tyres of wheels; and of making naves of wrought iron; of bending the plates of springs to the required shape, and in sawing the axle guards out of plates of iron, brought to a red heat.

1845. Emanuel Henry. Improvements in atmospheric railways.
the atmospheric tube is formed in the side of the tube, and the valve is closed by the pressure of a long bag or hose, inflated with tected by a shield of wrought iron bolted to the tube.
um in the tube is produced by first filling with water large close connected with the tube by pipes and valves, and the opening the tion between the two, and allowing the water to run off.

1845. J. R. Hill. Certain improvements in atmospheric propulsion to water as well as land carriages.

1845. M. Poole. Improvements in rails for railways.

1845. T. R. Crampton. Improvements in locomotive engines and

1845. F. Harlow. Improvements in atmospheric railways.

1845. S. Reed. Certain improvements in railway rails and chairs.

1845. T. Worsdell. Certain improvements in apparatus to be attached ployed in connexion with, railway carriages.

1845. J. Orsi. Improvements in sleepers or blocks for supporting Described at page 425.

1845. Fuller. Improvements in the construction of railway

1845. R. W. Brandling. Improvements in railways and railway the security and convenience of the public.

1845. C. H. Collins. Improvements in atmospheric railways.

1845. D. Crawford. Improved means of, or machinery for, arrest-ress of railway carriages and trains.

1845. J. Forsyth. Certain improvements in signals, or in the giving signals, which are applicable to the working of railways, and also applicable to maritime purposes, and for certain improve-rking of railways.

1845. B. Donkin. Improvements on wheels, as applicable to rail-ges, and on the mechanical contrivances by which railway carriages cross from one line to another line, or on to what are generally ngs."

1845. G. H. Dutton. Certain improvements in conveying intelli-one part of a railway train to another.

1845. J. O. Ward and W. Hillis. Improvements in the construction and in machinery and apparatus for working carriages.

1845. C. Vaux. Improvements in apparatus or machinery for accidents to carriages and passengers on railways, part of which its are applicable to save lives and property in other places.

1845. E. B. Wilson. Improved apparatus applicable to swivel turn-tables.

1845. H. B. Powell. For certain improvements in carriages to be and other roads.

1845. Ernest Edge. For certain improvements applicable to the axles of engines, tenders, carriages, and waggons, to be used upon

1845. Robert Rettie. For an improved method of signalizing or on sea or land, preventing collision at sea, and giving signals of improved burners with glasses coloured and signal cards, applicable all the various departments, as well as preventing of accidents, n is at full speed; also the diurnal for railways, towns, villages, &c.

1845. J. R. Johnson. For improvements in the materials employed ing and working atmospheric railways.

1845. Taylor and Conder. Improvements in propelling on rail-ribed at page 509.

1845. T. Swinburne. For improvements in railways, and in the opelling and carrying thereon.

1846. C. H. Greenhow. For improvement in the construction of railway carriages.

6th Jan. 1846. J. R. Bosek. For improvements in the construction and application of railroad carriage wheels.

13th Jan. 1846. R. B. Longridge. For an improved locomotive engine.

20th Jan. 1846. R. A. Brooman. For certain improvements in railway and common road carriages.

22d Jan. 1846. C. Wheeler. Certain improvements in the construction and working of railways.

22d Jan. 1846. F. W. Campin. Certain improvements in obtaining and applying motive power.

31st Jan. 1846. M. Rimington. Certain improvements in obtaining and applying motive power.

31st Jan. 1846. A. Etienne. Improvements in the construction of railways, railway carriages, and in the means of preventing accidents on railways.

3d Feb. 1846. E. Chesshire. Improvements in apparatus to be applied to railway carriages, to reduce the prejudicial effects of collisions to passengers in railway carriages.

3d Feb. 1846 S. Brown. Improvements in gas engines, and propelling carriages.

11th Feb. 1846. Clark, Freeman, and another. Improvements in obtaining and applying motive power.

11th Feb. 1846. G. Stephenson. An improvement in locomotive steam engines.

16th Feb. 1846. Nasmyth. Improvements in engines, or machines for obtaining and applying motive power.

19th Feb. 1846. R. Nisbet. Improvements in locomotive engines.

27th Feb. 1846. J. S. Templeton. Improvements in propelling carriages on railways, and improvements in propelling vessels.

11th March, 1846. W. Nairne. For a new mode or new modes of propelling carriages along railways.

11th March, 1846. H. Austin. Improvements in the construction of railways and railway carriages.

11th March, 1846. H. Bovill and another. Improvements in apparatus applicable to the working of atmospheric and other railways, canals and mines, and improvements in transmitting gas for the purpose of lighting railways.

11th March, 1846. J. Banfield. Improvements in making signals and communications on railways and between railways, engines, carriages, and trains, which are also applicable to other localities.

23d March, 1846. J. H. Gandell and another. Improvements in the construction of, and in the mode of opening and closing of, moveable bridges or arches, for the purpose of carrying railways, tramways, or other roads, across canals, locks, docks or other open cuttings.

25th March, 1846. T. Pope. Improvements in apparatus for moving railway carriages on to railways, and in machinery for lifting or moving heavy bodies.

18th April, 1846. E. Galloway. Improvements in locomotive engines.

7th April, 1846. T. Melling. Improvements in marine stationary and locomotive engines.

28th April, 1846. C. de Bergue. Improvements in atmospheric railways.

22d May, 1846. H. G. Hulme. Improvements in the construction of railways, and in the carriages to be used thereon.

26th May, 1846. J. Montgomery. Improvements in the construction of steam boilers and steam engines, and in steam vessels, and in the machinery for propelling the same.

26th May, 1846. E. A. Cowper. Improvements in the manufacture of railway chairs.

4th June, 1846. J. C. Robertson. Improvements in railways and railway carriages.

17th June, 1846. W. Cormack. Improvements in obtaining motive power.

10th Dec. 1846. T. V. Allier. For improvements in brakes or machinery for stopping or retarding carriages.

INS. Grapes, prepared by suffering them to remain on the vine till perfectly ripe, and then drying them in the sun, or by the heat of an he former are esteemed as much the best.

IDITY. That sensible change which first takes place in oils, when for some time to the air; supposed by chemists to be analogous to the of metals. For it appears that the processes employed to counteract depend upon the combination of oxygen with the extractive principle h the oily principle is naturally combined.

FACTION. The act whereby a body is brought to occupy more expand into a larger bulk, without the apparent accession of any new This is commonly regarded as the effect of heat, or the matter of pelling the particles of the body rarefied farther from the centre of on.

T. A species of file, on which the cutting prominences are distinct, being punching with a point, instead of cutting with a chisel.

AFIA. An alcoholic liquor prepared from the kernels of various kinds particularly those of cherries and apricots.

AN. A kind of cane much employed in the useful arts. They grow on along the banks of rivers in parts of Asia and the neighbouring Certain species furnish cables, cords, and withes, of exceeding strength; e split into strips for making the seats and backs of chairs, baskets, and t and elegant articles of furniture; those which are larger and firmer, e joints are more distant, afford elegant walking-sticks.

CH. A bar containing angular teeth, into which a pall drops, to pre-hines from running back. A circular ratch is called a ratchet wheel.

IFICATION. A careful repetition of distillation, by which the results ed. See ALCOHOL.

D. That part of a loom resembling the teeth of a comb, between which ds of the warp are separated.

LS. Rotatory cylinders, or frames, on which lines, threads, &c. are wound.

MING. The opening of the seams between the planks of vessels, by rons, for the purpose of caulking or re-caulking them with oakum.

INING, in *general*, is the art of purifying any thing; but the term is ly understood to apply to the purification of metals, particularly gold r, from the alloys with which they may be mixed. As gold and silver resist the combined action of air and fire, there is a possibility of puri-d and silver from all alloy of the other metals merely by the action of fire nly keeping them fused till all the alloy be destroyed; but this purifi-ould be very tedious and expensive, from the great consumption of fuel. lloyed with copper has been exposed above sixty hours to a glass-house hout being perfectly refined: the reason is, that when a small quantity ther metals remains united with gold and silver, it is protected from n of the air, which is necessary for combustion. This refining of d silver merely by the action of fire, which was the only method y known, was very tedious, difficult, imperfect, and expensive; but a orter and more advantageous method has been long practised. This n adding to the alloyed gold and silver a certain quantity of lead, and ing this mixture to the action of fire. The vessel in which the refining med, is hollow, but shallow, that the matter which it contains may pre-e air the greatest surface possible. This form resembles a cup, and s called a cupel. The furnace ought to be vaulted, that the heat may d to the surface of the metal during the whole time of the operation. s surface a dark-coloured crust or pellicle is always forming; but when her metals are dissipated, the surface of the gold and silver is seen clear nt; which indicates that the metal is free from alloy.

ECTION, *in Mechanics*, is the return or regressive motion of a move y, arising from the reaction of another body on which it impinges. The of bodies after impact, is attributable to their elasticity; and the more they possess this property, the greater will be their reflection, all other ers being the same.

REFRACTION, *in Mechanics*, is the deviation of a body in motion from its original course, arising from the different densities of the several parts of the medium through which it passes.

REFRIGERATORY, *in Chemistry and Distillation*, is a vessel for cooling liquids, or condensing vapour into liquids, by the application of cold water. The common worm-tub is a specimen; but refrigeratories are of numerous forms. See ALCOHOL, CONDENSER, &c.

REGISTER. An aperture or valve placed in a chimney, stove, or furnace, for regulating the quantity of air to be admitted.

REGULUS. A term that was given to metallic matters when separated from their ores by fusion.

RELIEVO, or RELIEF, are terms applied to that mode of working in sculpture by which figures are made to project from the ground or body on which they are formed, and to which they remain attached. The same term is used whether the figure is cut with the chisel, modelled in clay, or cut in metal or other substance. There are three kinds of relievo:—First, alto-relievo, (or high relief,) when the figures are so prominent from the ground, that merely a small part of them remains attached to it. Mezzo-relievo, (or half relief,) when half of the figure rises from the ground, in such manner that the figure is divided by it. Basso-relievo, (or low relief,) when the work is raised but little from the ground, as in medals, and generally in friezes, and other ornamental parts of buildings. Low-relief, or bas-relief, is the comprehensive term by which all works in relievo are usually indiscriminately denominated.

RENNET. The coagulum prepared from the stomach of a calf, employed in making cheese.

REPULSION, *in Physics*, that property in bodies, whereby if they are placed just beyond the sphere of each other's attraction of cohesion, they mutually recede and fly off.

RESIN. A solid inflammable substance of a vegetable origin, and soluble in alcohol; it resembles gum in appearance, but differs from it chiefly in its insolubility in water; in which gum is soluble, and not in alcohol. Resins appear to have been volatile oils rendered concrete by the absorption of oxygen. The exposure of these to the open air, and the decomposition of acids applied to them, evidently prove this conclusion. What is most generally known by the name of resin, or *rosin*, is the residuum left after distilling the essential oil of turpentine, and which is run or ladled out of the still into casks cut in half for sale. In commerce, this product is called *brown rosin*. The *yellow rosin* is made by ladling out the brown rosin from the still into a vessel of hot water; a violent effervescence ensues, and the rosin absorbs one-eighth of its weight of water. It is more friable than the brown rosin, but the lighter colour of the yellow adapts it better to some purposes.

RESISTANCE, *in Fluids*, is that opposition to the motion of a body which arises from the inertia, tenacity, and friction of the parts of the fluid in which it moves. If any body move through a fluid with a given velocity, it must evidently displace a certain number of particles with a given velocity; but by thus giving motion to the particles of fluid, it must lose a part of its own, which loss of motion is the effect of resistance. When a body changes its velocity, the resistance is not changed in the same proportion; for if a body move with double its former speed, it will manifestly set in motion twice as many particles, and each of these particles will be moved with double its former velocity. In the same way, if the velocity be tripled, three times the number of particles must be put into motion with a triple velocity. Thus it appears that a double velocity produces a fourfold resistance, a triple velocity a ninefold resistance; that is, the resistance increases proportionally to the square of the velocity. The resistance is also increased in the same proportion as the area of the surface immersed; it is also increased as the density of the fluid medium. If the body does not move with its face perpendicular to the direction of its motion, the resistance will be diminished, both on account of a less surface being exposed, and the oblique action of the particles on the plane. From these two causes the resistance will be diminished as the cube of the sine of the angle the

plane makes with the direction of its motion. The resistance is the same, whether the body move in the fluid, or the fluid move against the body. The absolute resistance to a given plane, by a fluid acting with a certain velocity perpendicularly to its face, is equal to the weight of a column of fluid, whose base is the plane and height equal to that through which a heavy body must fall to acquire the given velocity: a consideration of the law of resistance, a limit to our speed in navigation, which soon becomes insuperable.

RESOLUTION OF FORCES, or *resolution of motion*, is the act of dividing any single force or motion into two or more others, in different directions; or of finding the quantities of two or more forces or motions, which, taken together, shall produce the same quantity of force or motion with the given one, and in the same direction. This is the reverse of COMPOSITION OF FORCES or MOTION; which see.

RETARDATION. The act of checking or diminishing the velocity of a body in motion. The two grand causes of the retardation of moving bodies are, the resistance of the medium through which the body moves, and the action of gravity.

RETORT. A vessel used in distillatory processes, usually of a pear shape, with a long beak; but they are modified in a great variety of ways. See GAS.

REVERBERATORY. A furnace or oven, wherein the flame, or current of heated gases from the fuel, is caused to reverberate, or be reflected down upon the substance under operation, before passing into the chimney: such reverberatories are therefore usually made with dome tops, against which the flames &c. first impinge, and then curve downwards upon the bed of the furnace.

RHODIUM. A new metal, discovered by Sir H. Davy amongst crude platina; specific gravity, 11. It unites easily with every metal with which it has been tried, except mercury: with gold or silver it forms a very malleable alloy, not oxidated by a high degree of heat, but becomes encrusted with a black oxide when slowly cooled; one-sixth of it does not perceptibly alter the colour of gold, but renders it much less fusible.

RICE. A hard, white, farinaceous, and very nutritive grain, which grows in the East and West Indies, and other warm climates; it grows to the height of about 2½ feet, with a stalk not unlike that of wheat, but fuller of joints, and with leaves resembling those of the leek. It branches out into several stems, at the top of which the grain grows in clusters, and each of them is terminated with an ear or beard, enclosed in a yellow rough husk. When stripped of this rough coat and a thin under-skin, the grain is shown to be of an oval form, and of a beautiful white colour. The native mode of shelling rice (or paddy, as it is called in the rough state) in India, is by placing it in a large hollow stone or mortar, and striking the loose grain with a conical stone or pestle, by which it is constantly forcibly pressed and disturbed; and thus, by persevering efforts, the husks are rubbed off. This process is, however, a very tedious and laborious one, and to remedy it, a variety of inventions have been successfully introduced and improved upon. The general practice, of late years, has been to employ millstones for depriving the paddy of the outer shell, the stones being set at such a distance apart as will detach the shell, without crushing the interior grain. The stones are covered by a hoop or case, which entirely encloses them, leaving a space all round between the stone and the hoop of about two inches. In one side of this hoop is a hole, through which the husked rice runs out upon a fine sieve, kept agitated by the mills; in passing over this, the dust and sand are separated; it then falls into the winnowing machine, which separates the husk from the rice. There is one of these machines to each pair of stones, to separate the rice from the husk, in its passage from the stones to the bin.

The rice in this stage of the operation is more or less red, nothing more being done than the separation of the husk; after this, it is taken to the whitening machine, where the inside cuticle, or red skin, is detached. This machine consists of a stone of coarse grit, fixed on a spindle like a grinding-stone; the stone is enclosed in a case made nearly to fit, leaving a space all round of about an inch between the stone and the inside of the case: this case is made of plate iron, and punched full of small holes, like a grater, with the

rough side inwards; it is so contrived, that the case may go round with the stone, or it may remain still while the stone is turning. The rice is put in between the case and the stone at a sliding door, or opening in the case. The space is about two thirds filled; the stone is then put in very rapid motion, making at least 250 revolutions a minute, by a strap. The case is allowed to turn very slowly; this changes the position of the rice, and every grain in succession comes into contact with the stone, and, rubbing hard against one other, an accumulation of heat (which produces an enlargement of the grain, and consequently splits the red skin) is produced, which serves to loosen the skin; and this, forming a red dust, finds its way out of the holes in the case, and leaves the rice perfectly white.

The cleansing of rice in this country is of modern introduction, and, from its apparently growing importance, we shall add some account of the processes recently patented for that purpose.

Mr. Ewbank's patent of 1819 informs us that the paddy is first cleaned from foreign matter by passing it over a screen, which, detaining the rice, allow the impurities to pass through. The paddy in this state is taken to mill-stones, set at a proper distance apart to rub off the external shells or husks; the husks are next blown away by a fanning machine; the rice, thus partly cleaned, is then deposited in mortars, where it is beaten and triturated for depriving it of the thin red skin; and when the trituration has been carried far enough, the contents of the mortars are sifted upon a "sloping and revolving screen," which is composed of three distinct wire-cloths, of different degrees of fineness. The finest under cloth allows the dust or flour to pass through, but detains the broken rice; the second or middle cloth separates the broken, and detains the whole rice, while the coarsest upper cloth allows only the whole rice, or husked grains to pass through, and detains the unhusked, which is taken back to the millstones to be operated upon again. The rice, still but imperfectly clean, is afterwards taken to the polishing and whitening machine, which consists of two cylinders placed concentrically; the exterior cylinder is fixed or stationary, and the interior one, which is made to revolve, is covered with sheep-skins with the wool on the outside. Between these two cylinders the rice is put, and the inner cylinder being made to revolve, the rice is brushed by the constant friction of the wool, and thereby polished and whitened.

A second patent granted in May, 1827, to Messrs Lucas and Ewbank relates to an improved method of treating the rice, that is, after it has been husked. For the purpose of depriving or getting rid of the red pellicle, which is united to the rice by a gummy substance, they employed in succession two or more sets of mortars. When, by the trituration of the pestles, the gum or glutinous matter begins to disengage itself (which is immediately manifested by the rice moving sluggishly under the pestles), it is to be taken out of the first set of mortars, and carried to a second set, wherein is to be mixed with the rice a quantity of the external husks well dried, in the proportion of one-fourth or two-fifths in bulk to that of the rice. The triturating and beating process is then renewed upon this mixture, the dry husks greatly assisting in cleaning and whitening the grain. After this the mass is to be fanned and screened, to separate the refuse; when the rice is taken to the polishing machine, as before described, which terminates the process.

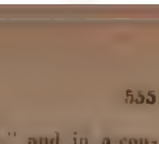
In the month following the date last mentioned, Mr. Melvil Wilson, a merchant of London, took out a patent for an improvement in husking rice, in which the operation was conducted simply by the collision of the grains of paddy against each other.

The apparatus consists of a long hollow cylinder, around the interior surface of which are fixed a series of angular bars, projecting towards the axis of the cylinder; this cylinder revolves loosely on a central shaft, which passes through it, and is provided with a similar number of bars, pointing radially from the centre to the circumference, and passing alternately between the bars in the cylinder, so as to leave an inch free space between them. Thus disposed, the cylinder is placed in an inclined position; the rice is allowed to enter at the top, while the cylinder is made to revolve with a "slow motion" on one

the axis moving at the same time at "a high speed," and in a con-
ection; consequently, as the rice passes through the cylinder, it will
iderably agitated and turned about; and the husk will, it is said, be
off before passing at the lower end of the cylinder.

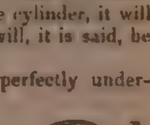
nder the construction of the interior of the cylinder perfectly under-
he annexed diagrams will be sufficient.

1



1 represents a plan of the cap of the cylinder, not
reto, nor to the axis, which passes through it, but
raming which supports the hopper; it serves to
he grain into the cylinder, and to keep out adven-
ubstances.

2

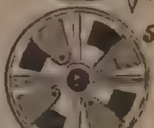


2 is called, in the specification, "a socket wheel;"
d directly under the cap to the cylinder, and the
ses through the socket, which serves, therefore, as
g for both the axis and the cylinder, permitting
o revolve freely in contrary directions. For the
ence of removal, this wheel is made to divide into
es, which are bolted together when in use.

3

3 gives a transverse section of the cylinder and
h of which being shown as provided with four
e number being fixed in each parallel circle, and
ly as respects those on the cylinder, and those on
s. This section likewise shows the cylinder to be
d of eight distinct pieces or segments; on each of
e segments is fixed a longitudinal row of similar
ough only four (the number in one circle) are
into view, to prevent confusion.

4 5



4 is a transverse section of one of the before-men-
ters, showing that they are of the figure of a quad-
e prism, that shape being preferred by the patentee
purpose in question.

5 is a plan of the bottom of the cylinder; it is
in part like the socket wheel, described in *Fig.* 2,
spaces between the spokes are closed; in each of
mpartments a large aperture is made for the
e of the grain, which is regulated at pleasure, by sliding doors to each,
ented.

Wilson took out a second patent in 1830 for "an improved method of
g and cleansing paddy or rough rice," which may be briefly described
ting of a series of mortars with solid bottom and *sieve sides;* the latter
ade of wire gauze, or perforated metal plates, strengthened by ribs of
re. These mortars are placed in a row, and their contents operated upon
es of pestles suspended to a revolving crank shaft above, the pestle rods
ided in their action by a suitable frame underneath, sliding between
standards which support the crank shaft. The intention of the "sieve
the mortars is, that the rice may pass through as soon as it is cleaned,
e to be heated by the subsequent operation of the pestles.

hall mention one more patent, which was recently granted to Mr.
f Liverpool, for the same object. Instead of a pair of millstones for
operation of shelling, the specification of this patentee directs the em-
t of *one* mill-*stone*, and what we will take leave to call *one* mill-*wood*
ely similar figure to the stone), and between these two substances the
s to be milled in the same manner as between two stones. The second
n of taking off the thin pellicle is to be performed by rubbing the
tween the flat surfaces of two wooden runners, which are covered with
s with the wool on. But Mr. Shuel's mode of applying the sheepskin
t to Mr. Ewbank's before described; the wool being placed by Mr.
t to the surface of the runners, so that the rice is operated upon by
sides of the skins, and owing to the springiness of the wool underneath,
e receives an elastic pressure.

RIFLE. The name given to a fire-arm from the peculiar construction of its barrel, which is cut internally into long spiral grooves, that usually make but one revolution through its length.

RIGGER. A cylindrical pulley; known also by the term drum, in machinery.

RIGGING. A general name given to all the ropes employed to support the masts, and to extend or reduce the sails, or arrange them to the disposition of the wind.

ROADS. The subject of this article opens to us so vast a field of inquiry, that it is impossible to do justice to its importance within the limits prescribed to us. To the curious explorer of ancient records, a search into the history of roads, from the earliest ages of antiquity, would repay his utmost labour. While to the philosopher it offers ample scope for meditation and reflection, the theorist may speculate on the influence, moral and political, exercised by facility of communication between distant members of the same body politic; and the sound reasoner find, in the opening of good roads alone, data on which to base a true estimate of the progress of society.

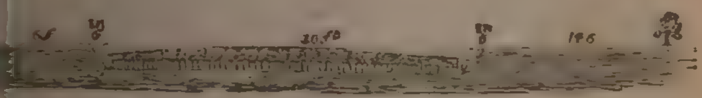
Roads may be described as both the cause and effect of civilization; the formation of roads invariably tending to improve the most barbarous district, to evolve its resources, and civilize its people; while, on the other hand, the internal communications of a country afford the surest proof of her prosperity; and her roads, the infallible signs, because the certain consequences, of her civilization. "Let us travel," says the Abbé Raynal, "over all the countries of the earth, and wherever we find no facility of travelling from a city to a town, or from a village to a hamlet, we may pronounce the people to be barbarians." "The making of roads," observes Sir Henry Parnell, in his admirable *Treatise*, "in point of fact, is fundamentally essential to bring about the first change that every rude country must undergo, in emerging from a condition of poverty and barbarism."

The wise policy of the Romans taught them to lay open the countries they subdued, which might afford an easy transport of their ammunition and supplies. In Britain, some remains of the Roman roads are yet visible. At Chester, remnants of the old Roman pavement, called the Castrum, are frequently discovered on removing the superincumbent soil; in Scotland, a portion of Roman causeway, leading from Musselburgh Bay to Abercorn; in the neighbourhood of St. Albans on the road to London—and in many other places. All the roads discovered ran nearly in direct lines. Natural obstructions were removed or overcome by the efforts of labour and art, whether they consisted of marshes, lakes, rivers or mountains. In flat districts the middle part of the road was raised into a terrace. In mountainous districts the roads were alternately cut through mountains and raised above the valleys, so as to preserve either a level line, or a uniform inclination. They founded the road on piles where the ground was not solid, and raised it by strong side walls, or by arches and piers, where it was necessary to gain elevation. The paved part of the great military roads was 16 Roman feet wide, with two side ways, each 8 feet wide, separated from the middle way by two raised paths, 2 feet each. At every mile columns were erected, to mark the distance from place to place; blocks of stone for foot travellers to rest upon, or for horsemen to mount their steeds with; temples, triumphal arches, and mausoleums adorned them, and military stations defended and commanded. By the formation of these great highways, an impulse was given in Britain to the national industry. The genius of the British people, essentially commercial, hastened to avail itself of the facilities (limited as they were) for intercourse and traffic; and we may fairly attribute to the conquest of Britain by the Romans her present commercial superiority.

A road should combine the qualities of hardness, smoothness, and strength or solidity. To obtain these requisites, it appears to us indispensable that great care should be taken to prepare the foundation for the materials; but on this point much diversity of opinion exists; Mr. M'Adam maintaining that the elasticity of the subsoil is rather a benefit than an injury, in contradiction

…ion of Mr. Tredgold, and other eminent engineers, that on a substratum …ngy nature, as bog-land, or morasses, it is imperative to render the …on firm.

…nage.—In properly conducting this part of the business of road-making, …e is necessary. The utmost judgment of the skilful surveyor will be …to action to enable him to make the best use of the natural facilities of …ntry, and to overcome the obstructions that he will sometimes meet with. …ng over flat land, open main drains, cut on the field side of the fences, …mmunicate with the natural watercourses of the country; they should … feet deep below the level of the bed of the road, one foot wide at … and five feet wide at top. If springs rise in the site of the road, or in …s of deep cuttings, stone or tile drains should be made into them. In … small drains, technically called mitre drains, should be formed; the …epending on the inclination of the road, should not exceed 1 inch in …hey should be 9 inches wide at bottom, 12 inches at top, and 10 inches …ccording to the inclinations of a road, and the form and wetness of the … cross-drains of good masonry should be built under the road, having …tremities carried under the road fences. One of these should be built …e water would lie; and when the road passes along the slope of a hill, …mbers are necessary to carry off the water that collects in the channel …ad on the side next the high ground. Various descriptions of drains …e in every situation where necessary, and the preservation of the … the road secured by giving it a proper convexity in its cross section, … in the annexed section, designed for the regulation of the surfaces …ies between the fences of the Holyhead road.



…oper convex form is particularly essential on hills, in order that the …y have a tendency to fall from the centre to the sides. The side …, and all the road drains, should be repaired at the approach and at the …e winter, and daily attention given to their being free from obstruction. … by a proper system of drainage, be kept dry, they will be maintained … state, and at proportionally less expense.

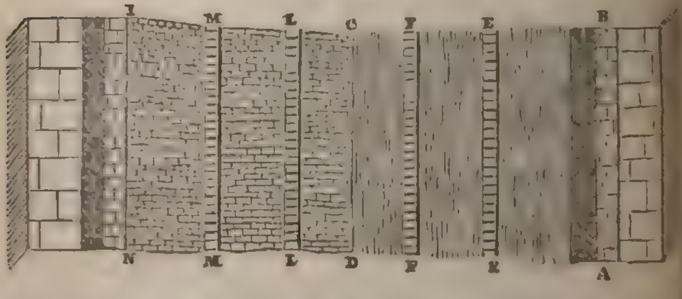
…als, &c.—The breadth of roads should vary according to circumstances. …cinity of large towns, where the traffic is considerable, the road should … than 60 feet between the fences. Where there is less traffic, fifty …e sufficient. The whole breadth should, in these cases, be *metalled*, …ith broken stones. Near London, and the capitals of Edinburgh and … perhaps 70 feet is not too great a width, and a footpath should be pro… each side. "The road," says Mr. Telford, in a specification for th… … road, "is to be 30 feet wide, exclusive of footpaths, with a fall of 6 …m the centre to the side channels." The bed of the new road bein… … for the reception of the materials, should, if of a wet or spongy natur… … '*rammed*' with chips of stone; in some situations it is advisable to lay … of *hand-laid* stones, of from 5 to 7 inches in depth, with their broad… placed downwards, and the whole built compactly together. On this … laid the '*metal*,' or broken stones, to the depth of at least 8 inches, … a uniform size, so as to form a solid and compact body. To insur… …y in the size of the broken stones, various tests have been suggested. …he most simple is, that every piece shall pass through a ring of 2… …iameter. On this body of metal, no binding or gravel should be used;

the angular sides of the metal soon lock into each other, and form a smooth surface. In the selection of road-metal, we prefer the several varieties of greenstone. The best kinds of these are less friable than granite, when broken into small pieces. It is, however, often necessary, for want of better materials, to use sandstone, common limestone, and chalk, even in districts where there is a great deal of traffic; in some instances, where coal is abundant, sandstone is reduced to a vitreous mass in kilns erected by the road side.

"Well-made roads, formed of clean, hard, broken stone," observes Mr. Macneill, "placed on a solid foundation, are very little affected by changes of atmosphere; weak roads, or those that are imperfectly formed with gravel, flint, or round pebbles, without a bottoming, or foundation of stone pavement or concrete, are, on the contrary, much affected by changes of the weather. In the formation of such roads, and before they become bound or firm, a considerable portion of the sub-soil mixes with the stone or gravel, in consequence of the necessity of putting the gravel on in thin layers: this mixture of earth or clay, in dry, warm seasons, expands by the heat, and makes the road loose and open; the consequence is, that the stones are thrown out, and many of them are crushed and ground into dust, producing considerable wear and diminution of the materials. In wet weather, also, the clay or earth mixed with the stones absorbs moisture, becomes soft, and allows the stones to move and rub against each other, when acted upon by the feet of horses or wheels of carriages. This attrition of the stones against each other wears them out surprisingly fast, and produces large quantities of mud, which tend to keep the road damp, and by that means increases the injury."

The immense traffic in the streets of London, and other large cities, and the inconveniences resulting from a frequent derangement of the pavement, have long rendered the establishment of a firm, durable, and smooth city road, a great desideratum. The alternate dust and mud on broken stone roads have proved them unfit for crowded thoroughfares. They have been tried, but failed. Stone paving of various kinds, and even cast-iron plates, in the form of

Fig. 1. (*Plan.*)



a causeway, have been suggested. Of the two kinds of stone pavement with which London, Dublin, and Edinburgh, are paved, the one is termed rubble causeway, the other aisler causeway. In the former the stones are very slightly hammer-dressed; in the latter they vary from 5 to 7 inches in thickness, from 8 to 12 in length, and about a foot in depth. The Commercial Road of London is a fine specimen of the aisler causeway. It leads from Whitechapel to the extensive establishments of the East and West India Docks, at Blackwall and Poplar. It is 2 miles long, and 70 feet wide. The footpaths are laid with Yorkshire flags, and the stoneway of granite. The tramway is composed of large stone blocks, 18 inches wide by 12 inches deep, and from 2½ to 10 feet long. They are laid in rows four feet apart, on a hard gravel bottom, or a concrete foundation, and have their ends closely and firmly jointed to each

so as to prevent movement, either lateral or longitudinal. On this tram- waggon weighing, with its load, 10 tons, was drawn by one horse from ...est India Docks, a distance of 2 miles, rising 1 in 274, at the rate of ...4 miles per hour. The works were executed under the direction of Mr. ... Walker, the engineer, by whom the plans were furnished, and whose ...to the trustees of the road contains much useful information.

...Stephenson, the engineer, describes in the *Edinburgh Encyclopedia* a mode ...structing a smooth and durable city road, which is both economical and ...ous.—" A street or highway, supposed to measure about thirty feet in

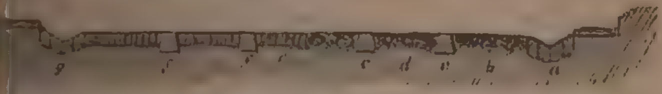


Fig. 2. (*Section.*)

..., is laid out in five compartments, independently of foot-paths. Two of ...e laid with the aisler causeway tracks, five feet apart, the horse-paths ...le causeway, or broken stones, in the usual way. A B C D (*Fig.* 1) point ...ompartment of the road, laid partly with broken stones, in which E E ...F are the aisler causeway tracks, A B being a paved open drain, on the ... the road. I N shows the limits of a road, also laid with tracks of ...auseway, as marked at L L and M M; but here the compartments ...s and on each side are paved with rubble, or inferior causeway stones. ...s a section of the plan described under *Fig.* 1, and shows the particular ... the aisler causeway tracks; *a* is a paved drain, *b* one of the sides, ...ith broken stones, *c c* two of the aisler causeway tracks, and *d* the horse- ...tween them.

...e year 1825, Mr. Thomas Parkins obtained a patent for an improved ... paving. The patentee proposed to lay on common roads continuous ... granite blocks, on which the wheels of carriages are to run; the upper ... are to be level with the road, the under surface flat, and the stones are ...gether by " bird's-mouth joints." Each stone is thus supported by the ...n each side of it, and prevented from partial depression. Whatever

Fig. 3.

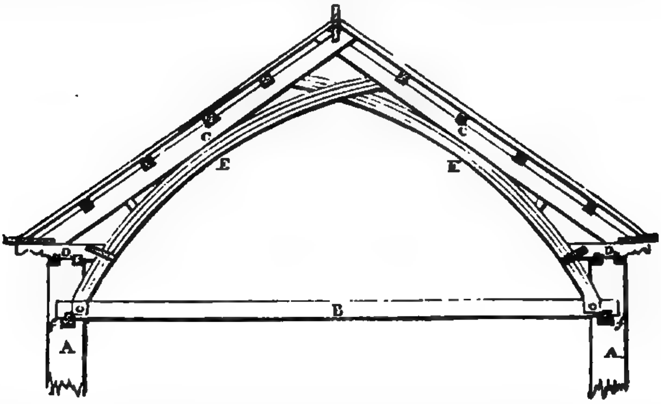
...ay be due to Mr. Parkins for the methods he has suggested, so many ...arious are the improvements in pavements since the date of his patent, ...s unnecessary to describe more minutely the several modes by which he ... to connect the blocks of stone together.

... same year, a patent was granted to Mr. John Lindsay, of the Island ...n, near Guernsey, for certain improvements in paving, it is described ...XI. No. 64, of the *London Journal*. *Fig.* 3 is a cross section of the ...D D is a properly-prepared foundation; *b* and *c c* are blocks of smooth ... placed longitudinally, and parallel to each other, for the carriage

wheels; *d d* are also stone blocks, with trenches in their upper surfaces, to se as drains for surface moisture or rain. The intermediate spaces *e e e e* are fil up by common paving stones, with their broadest surfaces downwards, interstices to be filled with granite chips or cement. The central line of gra blocks *b* is to be sufficiently broad to allow two carriages to pass; and the blocks *c c* are only required to be wide enough for one wheel to run on. U the kerbs, carriages with heavy loads will pass with ease, and comparati little labour to the horses. Mr. Lindsay's plan of preparing the foundation the reception of the blocks, it is unnecessary to detail; and we believe method of fastening the blocks by cramps or bars of iron, has been l known, and, in many cases, acted upon. Though we conceive his inventio possess but little novelty, the patentee deserves credit for *attempting* to impr our street pavement; so valuable, as we have before observed, in a smo and solid roadway, that every suggestion for its attainment is entitled respect.

Mr. H. T. Cassell of Mill Wall, Poplar, has obtained a patent for a bi minous composition, called by him "lava stone." The patentee describes merits of the invention to consist in the discovery of a mode of combin certain materials to form a species of stone uniting the advantages of m with those of stone. The properties of this stone are durability and toughn It does not absorb water, and is a non-conductor of heat. Each of these p perties can, in the process of combination, be increased or diminished, to the purposes for which the stone is intended. In paving a street, the follow method is pursued:—Instead of disturbing the bottom, it is to be consolida by picking, raking, and rolling. A coating of bituminous lava is then over, and the whole rendered impervious to water. This coating is then to paved over with granite stones of the usual description, and the interstices to be filled in with hot bituminous lava.

ROOF. The top covering to a house or other building; in which sense it co prises the timber work, slate, tile, lead, with whatever else is necessary to fo and complete the whole. Roofs are of various forms. First, the *pointed* ro in which the ridge, or the angle formed by two rafters at the point at top wh they meet, is an acute angle. Secondly, the *square* roof, in which the angle the ridge, formed as above, is a right angle. Thirdly, the flat roof, or rath



pediment roof, which has the angle at the ridge more or less obtuse. There various other forms, as the hip-roof, the valley-roof, the hopper-roof, the box roof, the round roof; and when the covering of a building is flat, it is de minated a platform, technically, and not a roof. For a full and exact descrip of every kind of roof, we must refer the reader to Nicholson's *Pract Builder*, contenting ourselves by presenting to him a very elegant

nomical arrangement for a pediment roof, recently designed by A. H ouldsworth, Esq., for the presentation of a model of which to the Society of s, &c., that gentleman was awarded an honorary medal. It is represented the cut.

The advantages which this method affords, are, the saving of a considerable portion of the timber usually employed, and the gaining for useful purposes whole space that is contained within the roof. Mr. Houldsworth constructed oof of this kind over the dwelling-house of a friend of his, and notwithding his walls were only six feet above his upper floor, he has obtained, in sequence, good lofty rooms, whilst the outside of his house appears very . his barns, hay-lofts, &c., are built upon the same plan. A A represent walls of the house, and B one of the timbers of the uppermost floor, resting the sleepers *f f*, which are let into the wall; over two other sleepers, laid in top of the wall, are fitted two pieces of wood, D D. The principal rafters , forming each pair, are then secured at the bottom into the pieces D D, and fastened to each other at the top by iron pins. Each pair of the principal ters C C is supported by two arch pieces E E; these pieces are in *their grain*, are formed on the plan recommended by Mr. Hookey, of the King's Yard, Woolwich, to whom the country is so much indebted for this mode of coning the timber. They are cut lengthways, by a saw, into three pieces, to in two feet of one end; are then placed in a steam-kiln, and boiled until will bend freely, when they are fixed to a mould and left to cool; after ch a few pins of wood are driven through them, to keep the pieces so cut m again flying open. The arch pieces will get a little out of shape when en from the mould, but will be easily brought back, and when secured under principal rafters, will fit the more firmly. The lower ends of these arch es are inserted in the beam B of the floor, and therein firmly pinned, while he top they cross one another, and each butts against its opposite rafter. y are further secured by iron straps to the short pieces D D, on which the cipal rafters rest, thus preventing the latter from sinking, and thrusting out walls, and making the whole a stiff and complete framing, on which the itudinal rafters and transverse pieces are fastened in the usual manner.

he roofs of barns or other buildings that have only a ground floor, may be structed in the same way, care being always taken to bring the feet of the h pieces so far down the wall as to give them a firm bearing.

Mr. Houldsworth, having already constructed several roofs of great widths on plan described, expresses his entire confidence of being able to apply the principle to a roof of any given span, for which timber of sufficient length ld be procured. This elegant improvement, which does away with all those onvenient timbers in roofs of the ordinary construction, called king-posts, en-posts, braces, &c. &c., consequently leaves the whole space (as before rved), which is usually employed to no useful purpose, for the making of d lofty rooms, besides effecting a considerable saving on timber. Numerous mples of the modes of trussing girders for roofs are given under the article R.

ROPE-MAKING. The art of forming fibrous, flexible, and tenacious subces into cordage. The principal aim of the ropemaker is to unite the ngth of a great number of fibres. This would be done most effectually, the fibres long enough, by laying them parallel to each other, and fastening bundle at each end. They must therefore be combined together in such a ner that the strength of any single fibre shall be insufficient to overcome resistance of the friction occasioned by the entanglement, but rather break: this effect is found to be produced most easily by twisting them together, so they shall mutually compress each other. On the other hand, a skein may be ed so hard, that any attempt at farther twisting will break it; such a can have no strength to support a weight, each fibre being already loaded uch as it can bear, and therefore any weight added would break it. Whatforce is actually exerted by a twisted fibre, in order that it may sufficiently press the rest to hinder them from being drawn out, must be considered as ght hanging on that fibre, and must be deducted from its absolute strength

[illegible] the strength of the skein can be estimated. The strength of [illegible] the remainder of the absolute strength of the fibres after [illegible] twisting them has been deducted. Hence arises that fun- [illegible] rope-making, namely, that all twisting beyond what is [illegible] preventing the fibres from being drawn out without breaking, [illegible] strength of the cordage, and is, therefore, to be avoided. Thus [illegible] twist the fibres of hemp together, in order to make a strand, [illegible] all something must be done to prevent the skein from [illegible] as soon as it is let loose from the hand; some method must be [illegible] the tendency to untwist in one part, act against and counter- [illegible] tendency to untwist in another; in the properly accomplishing [illegible] of the principal difficulties of rope-making. The following [illegible] distinctness' sake, apply chiefly to the larger cordage, such as [illegible] and running rigging of a ship; but they are easily extended [illegible] modifications, to the smaller kinds.

[illegible] part of the rope-making process consists in twisting the hemp; that [illegible] rope-yarns. These are spun in various ways, according to the nature [illegible] machinery employed, and the cordage to be made. A slip of level [illegible], of about 600 feet long, of a breadth sufficient to contain [illegible] machines employed, and either covered with a slight roof, or left [illegible]. A spinning-wheel is set up at the upper end of this walk. The [illegible] wheel goes over several rollers called whirls, turning on pivots in [illegible]. The pivots at one end come through the frame, and terminate in [illegible]. The wheel being turned by a winch, gives motion to all these [illegible]. The spinner has a bundle of dressed hemp round his waist, laid in the [illegible] that women spread the flax on the distaff. He draws out a proper [illegible] fibres, twists them with his fingers, and affixes them to the hook of [illegible]. The wheel is now turned, the skein is twisted, becoming what is [illegible] yarn, and the spinner walks backwards down the rope-walk. The [illegible] supports the yarn in one hand (protected by a wetted piece of coarse [illegible] flannel), while with the other he regulates the quantity of fibres drawn [illegible] bundle of hemp by the motion of the twisting yarn. The greatest [illegible] that can be committed, is to allow a small thread to be twisted off from [illegible] of the hemp, and then to cover this with hemp supplied from the other [illegible] it is evident that the fibres of the central thread make very long [illegible] while the skein of the fibres which covers it must be much more oblique. [illegible] has but little connexion with what is below it, and will easily be [illegible]. But even while it remains, the yarn cannot be strong, for on pulling [illegible] middle part, which lies the straightest, must bear all the strain. This [illegible] will always happen if the hemp be supplied in a considerable body to a [illegible] that is then spinning small. Into whatever part of the yarn it is made [illegible], it becomes a sort of loosely connected wrapper. A good spinner, [illegible], endeavours always to supply the hemp in the form of a thin, flat skein. [illegible] of twist depends on the rate of the wheel's motion, combined with [illegible] walk of the spinner. We may suppose him arrived at the lower [illegible] walk, or as far as necessary for the length of the yarn, he calls out. [illegible] spinner immediately detaches the yarn from the hook of the whirl, [illegible] another, who carries it aside to the reel, and this second spinner [illegible] his own hemp to the whirl-hook. In the mean time, the first spinner [illegible] hold of the end of his yarn; for the hemp, being dry, is very elastic, [illegible] were to let it go out of his hand, it would instantly untwist. He [illegible] therefore, till the reeler begins to turn the reel, and then walks slowly up [illegible], keeping the yarn of an equal tightness all the way.

[illegible] yarns, for large rigging, are from a quarter of an inch to somewhat [illegible] the third of an inch in circumference; or of such a size, that 160 [illegible] white yarn weigh from 3½ to 4 pounds. The number of yarns in a [illegible] cordage varies from sixteen to twenty-five. The yarns are made into [illegible] any length, by laying them; and that we may have a rope of any [illegible] strength, many yarns are united into one strand, for the same reason [illegible] fibres are united into one yarn.

The process for laying or closing large cordage, is as follows:—At the upper end of the walk is fixed a tackle-board. This consists of a strong oaken plank, called a breast-board, having several holes in it, fitted with brass or iron plates. To these are put iron cranks called heavers, which have forelocks and keys, at the ends of their spindles. This breast-board is fixed to the top of strong posts, and well secured by struts or braces. At the lower end of the rope-walk is a similar breast-board fixed to a movable sledge, which may be loaded with weights when necessary. A TOP, which is a truncated cone, having scores in its sides for the strands, a long staff, and supported on a sledge or carriage, is placed between the strands, and, when necessary, gently forced into the angle formed by their separation. A piece of soft rope, called a strap, is attached to the handle of the top, by the middle, and its two ends are brought back, wrapped several times tight round the rope, and bound down. The yarns are formed into strands, each of which is knotted apart at both ends. The knots at their upper ends are made fast to the hooks of the cranks in the tackle-board; and those at the lower end, to the cranks on the sledge. The sledge itself is kept in its place by a tackle, and a proper weight laid on it till the strands are stretched in their places. The tackle is now cast off, the cranks turned at both ends, and as the strands contract by the operation, the sledge is dragged up the walk. When the strands are sufficiently hardened, they are taken off the cranks, the cranks taken out, and a very strong crank put in the centre hole of the tackle-board. To this all the strands are now attached; the top is placed between the strands, as before described, and the heavers at the tackle-board and sledge continue to turn as before. By the motion of the sledge-crank, the top is forced away from the knot, and the rope begins to close. As this advances, the rope shortens, and the sledge is dragged up the walk. The top moves faster, and at last reaches the upper end of the walk, the rope being now laid.

Such is the general and essential process of rope-making; and in the course of this process, it is in our power to give the rope a solidity and hardness which makes it less penetrable by water. Some of these purposes are inconsistent with others; and the skill of a rope-maker lies in making the best compensation, so that the rope may, on the whole, be the best in point of strength, pliancy, and duration, that the quantity of hemp in it can produce.

The following rule for judging of the weight which a rope will bear, is not far from the truth. Multiply the circumference in inches by itself, and the fifth of the product will express the number of tons which the rope will carry. Thus, if the rope have 6 inches circumference, 6 × 6 = 36, the fifth of which is 7⅕ tons; apply this to the rope of 3¼ inches, on which Sir Charles Knowles made his experiments, 3¼ × 3¼ = 10.25; one-fifth of which is 2.05 tons, or 4,592 pounds. It broke with 4,550. This may suffice for a general account of the mechanical part of the manufacture: but we have taken no notice of the operation of tarring, because it would be no easy task to enumerate all the various methods employed in different rope-works. It is evidently proper to tar in the state of twine or yarn, this being the only way in which the hemp can be uniformly penetrated The yarn is made to wind off one reel, and having passed through a vessel containing hot tar, it is wound upon another reel, and the superfluous tar is taken off, by passing through a hole surrounded with spongy oakum; or it is tarred in skeins or hauls, which are drawn by a capstern, through the tar kettle.

Tarred cordage, when new, is weaker than white, and the difference increases by keeping. The following experiments were made by M. Du Hamel, at Rochefort, in 1743, on cordage of three inches (French) in circumference, made of the best Riga hemp.

Made August 8, 1741.

	White.	Tarred.
Broke with	4,500 pounds	3,400 pounds
,,	4,900	3,300 ,,
,,	4,800	3,250 ,,

	White.	Tarred.
Made April 25, 1743.		
Broke with	1,600 pounds. . . .	3,500 pounds
,,	5,000	3,400 ,,
Made September 3, 1746.		
,,	3,800	3,000 ,,
,,	4,000	2,700 ,,
,,	4,200	2,800 ,,

M. Du Hamel says, that it is decided by experience, 1st. That white cordage in continual service is one-third more durable than tarred. 2d. That it retains its force much longer while kept in store. 3d. That it resists the ordinary injuries of the weather one-fourth longer. Why, then, should cordage be tarred? The answer is, That tarring preserves cables and ground tackle, which are greatly exposed to the alternate action of water and air; for white cordage, exposed to be alternately very wet and dry, is found to be weaker than tarred cordage; and that cordage which is superficially tarred is always stronger than what is tarred throughout, and resists better the alternatives of wet and dry.

RULE. An instrument with lines, divisions, and numerals marked upon it, of the greatest utility in mensuration. There are, of course, numerous kinds adapted to their peculiar objects. The most extensively useful is unquestionably the carpenter's rule, for taking lineal measurements, which is therefore divided into feet, inches, and various parts, scales of proportion, &c. There are various sliding rules, for performing computations, others furnished with tables adapted to the use of all kinds of trades and manufactures, as well as professional persons. For rules especially designed for drawing parallel lines, see PARALLEL RULE.

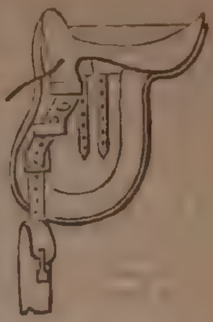
S

SACCHAROMETER. An instrument for ascertaining the strength of worts, in the preparation of malt liquor for beer or distilling spirit; its name, however, simply implies a measurer of saccharine matter or sweetness. See DISTILLATION.

SADDLE. A seat placed upon a horse's back, for the convenience of the rider. Among the recent patents having this object in view, we shall mention the leading features of two or three of them.

To give increased elasticity to the seats of saddles, Mr. Marsh employs fine wire springs, in lieu of the wool and other materials generally used in stuffing them, which are apt, by the compression of the rider, to become hard. The springs are of the kind used in garters and elastic braces. They are extended in rows from the front to the back of the saddle, upon the ordinary packing, and secured by sewing their ends to a web which is attached to the saddle. When this is done, the usual coating of cloth is put over the wire springs, and fastened down upon the covering of the packing below, by stitching in lines at small distances apart, crosswise of the saddle, by which means the rows of wire will be kept alongside of each other, and preventing from overlapping. The external covering forming the seat being now placed over the springs, and finished in the usual way, an elastic seat is produced, which, it is said, is much superior to any kind of packing before used.

Mr. Henry Calvert, of Lincoln, had a patent in 18[illegible], the object of which was to avoid the inconvenience and danger occasioned by saddles slipping



ward. The annexed cut represents one of Mr Calvert's, with the exterior cover and flap removed to show the construction. The improvement mainly consists in attaching to the ... part of the saddle-tree an elastic plate of metal extending in a sloping direction towards the front of the saddle; it is confined by two ..., which receive the girth strap; the proper shape of the sweat-flap is also shown. The small buckle which is fixed to the loose end of the girth is drawn up to the small strap after the horse is girthed. The front girth of course is strapped first, and the second not quite so tight. By this arrangement it will be seen that the saddle is kept in its place by the elasticity of the metal plate, and that it cannot move forward upon the horse without the girth being lengthened.

Messrs. Laurence and Rudder had a patent in the succeeding year for "an improvement in saddles and girths by an apparatus fixed to either of them;" the object of which was to give to saddle-girths an elasticity to preserve sufficient tension under the varying dimensions of the animals to which they may be applied. Saddle-girths, for instance, that have been put on immediately after the horse has been fed, must either be made inconveniently tight at first, or else they will become inconveniently loose as the size of the animal diminishes by the digestion of his food. The patentees denominate their girths the *constrictor* girths, and they are made by attaching to the saddle-tree by a pair of hinges a small shallow brass case containing a series of grasshopper springs, and behind the springs is a movable plate, to which the girth-straps are attached in such manner that when the movable plate is pulled down by the girth-straps the springs are collapsed, or brought into a position to exert their elasticity in preserving the tightness of the girth.

SAFFRON. The stigmata of the crocus officinalis, dried on a kiln, and pressed into cakes. The best saffron has the broadest blades,—this being the mark by which English saffron is distinguished from the foreign; it ought to be of an orange or fiery-red colour, and to yield a dark yellow tincture; it should be chosen fresh, not above a year old, in close cakes, neither dry nor yet very moist, tough and firm in tearing, of the same colour within as without, and of a strong, acrid, diffusive smell. This drug has been reckoned a very elegant and useful aromatic; it imparts the whole of its virtue and colour to rectified spirit, proof spirit, wine, vinegar, and water. A tincture drawn with vinegar loses greatly of its colour in keeping; the watery and vinous tinctures are apt to grow sour, and then lose their colour also; that made in pure spirit keeps in perfection for many years.

SAGO. A nutritive substance, brought from the East Indies, of considerable use in diet as a restorative. Sago is procured from a tree called landan, growing in the Moluccas: this tree is a species of the palm, which grows naturally in Japan, and upon rocky, dry mountains in Malabar, and its production is an universal article of food among the inhabitants of Amboyna, Ceram, Celebes, and the surrounding islands east of Celebes, and also in Borneo. The progress of its vegetation, in the early stages, is very slow: at first, it is a mere shrub, thick set with thorns, which make it difficult to come near it; but as soon as its stem is once formed, it rises in a short time to the height of thirty feet, is about six feet in circumference, and imperceptibly loses its thorns. Its ligneous bark is about an inch in thickness, and covers a multitude of long fibres, which, being interwoven one with another, envelope a mass of a gummy kind of meal. As soon as this tree is ripe, a whitish dust, which transpires through the pores of the leaves, and adheres to their extremities, proclaims its maturity. The Malays then cut them down near the root, divide them into several sections, which they split into quarters; they then scoop out the mass of mealy substance, which is enveloped by, and adheres to, the fibres; they dilute it in pure

water, and then pass it through a straining bag of fine cloth, in order to separate it from the fibres. When this paste has lost part of its moisture by evaporation, the Malays throw it into a kind of earthen vessels, of different shapes, where they allow it to dry and harden. This paste is a wholesome, nourishing food, and may be preserved for many years; the Indians eat it diluted with water, and sometimes baked or boiled: a jelly is sometimes made of it, which is white and of a delicious flavour. The finest part of the meal is mixed with water, and the paste is rubbed into little round grains like small shot, and dried. This is the sago of the shops.

SAL. The Latin name for salt, commonly adopted in chemical language as in the following examples, which require explanations:—

Sal-alembroth, a compound muriate of mercury and ammonia.

Sal-ammoniac, muriate of ammonia.

Sal-ammoniac, secret, sulphate of ammonia.

Sal de Duobus, sulphate of potash.

Sal-gem, native muriate of soda.

Sal-martis, green sulphate of iron.

Sal prunella, nitrate of potash.]

SALIFIABLE BASES. Those metallic, earthy, or alkaline substances which have the power of neutralizing acidity entirely or in part, and producing salts.

SALT. A term commonly used in chemistry to denote a compound in definite proportions, formed by the union of an acid with an alkaline, earthy or metallic base. We have already given a brief enumeration of some of the most remarkable, under the article CHEMISTRY. In consequence, however, of the progressive discoveries which for the last half century have been continually made, and are still making, in chemistry, many deductions, which, at the time they were made, were considered as conclusive facts, have since been either wholly abandoned, or subjected to considerable modifications. A salt has usually been denominated by chemists a *neutral* salt, when the proportions of the constituents are so adjusted, that the resulting substance does not affect the colour of infusion of litmus or red cabbage. When the predominancy of acid is evinced by the reddening of these infusions, the salt is said to be acidulous, and the prefix *super*, or *bi*, is used to indicate the excess of acid: thus we call one particular salt super-tartrate of potash, and another, bi-sulphate of lime, where the acid exists in excess. But when, on the contrary, the acid matter is in too small a quantity to completely neutralize the alkalinity of the base, the salt is said to be with an excess of base, and the prefix *sub* is attached to its name: thus we have the sub-phosphate of bismuth, &c.

The commercial name of a salt differs from that by which it is known to chemists: it may therefore be proper to show what kinds of salt are to be understood by the popular names which they bear in the shops.

Ammoniacal Mixed Salt, muriate of lime.

Ammoniacal Secret Salt of Glauber, sulphate of ammonia.

Arsenical Neutral Salt of Macquer, super-arseniate of potash.

Bitter Cathartic Salt, sulphate of magnesia.

Common Table Salt, muriate of soda.

Digestive Salt of Sylvius, or *Diuretic Salt*, acetate of potash.

Epsom Salt, sulphate of magnesia.

Febrifuge Salt of Sylvius, muriate of potash.

Fusible Salt, phosphate of ammonia.

Fusible Salt of Urine, triple-phosphate of soda and ammonia.

Glauber's Salt, sulphate of soda.

Marine Salt, muriate of soda.

Marine Argillaceous Salt, muriate of alumina.

Microcosmic Salt, triple-phosphate of soda and ammonia.

Nitrous Ammoniacal Salt, nitrate of ammonia.

Salt of Amber, succinic acid.

Salt of Benzoin, benzoic acid.

Salt of Canal, sulphate of magnesia.

Colcothar, sulphate of iron.
Egra, sulphate of magnesia.
Salt of Lemons, super-oxalate of potash.
Saturn, acetate of lead.
Seidlitz, sulphate of magnesia.
Seignette, triple-tartrate of potash and soda.
Soda, sub-carbonate of soda.
Sorrel, super-oxalate of potash.
Tartar, sub-carbonate of potash.
Vitriol, purified sulphate of zinc.
Wisdom, a compound-muriate of mercury and ammonia.
Salt, phosphate of soda.
Salt of Glauber, sulphate of potash.
Salt, boracic acid.
Salt, muriatic acid.
ous Salt of Stahl, sulphate of potash.
ful Salt, sulphate of soda.
ful Perlate Salt, phosphate of soda.'

dinary: is in chemical language the muriate of soda: but according discoveries, a chloride of sodium, being a compound of chlorine, with e base of soda. This salt is obtained by a variety of methods. It is out of the earth in a solid form, and dissolved, purified, and evapo-se; or sea-water is evaporated, either by natural or artificial means, obtained from the purified residuum. The most abundant supply of in this country is obtained from the mines in Cheshire, where the pumped up from the brine-pits, saturated with rock-salt, and then one hundred tons of the saturated solution of rock-salt in sea-water nd to yield about twenty-three tons of salt.

brated mines of Poland, whence the rock-salt has been continually in immense quantities for a period of upwards of five hundred years, mines, they have 20,000 tons ready for sale, is, however, not so pro-those in Cheshire. At Cordova, in Spain, there is a mountain of alt, from 400 to 500 feet high, and a league in circuit; the depth surface of the ground is unknown. In Louisiana, near the river here is said to be a mountain of pure rock-salt of the best quality, miles long, 45 miles wide, and of an immense height.

ers of the ocean every where abound with common salt, though in roportions: the average has been calculated to be about one-thirtieth ht. In the cold climates, the quantity of salt in the sea-water does to be nearly so great as between the tropics. In Russia, and other ountries, the salt is usually obtained from the sea-water, by freezing the ice, which is nearly fresh, being then removed, the remaining ry strong, and is subsequently evaporated by boiling. In the southern urope, and other warm countries, the usual mode of obtaining the spontaneous evaporation. A flat piece of ground near the sea is d banked round, to prevent its being overflowed at high water. The in the banks is divided by low walls into several compartments, essively communicate with each other. At flood tide, the first of led with sea-water; which, by remaining a certain time, deposits its and loses part of its aqueous fluid. The residue is then suffered to e next compartment, and the former is filled again as before. From compartment, after a due time, the water is transferred into a third, ed with clay, well rammed and levelled. At this period, the evapo-ually brought to that degree, that a crust of salt is formed on the the water, which the workmen break, and it immediately falls to the They continue to do this until the quantity is sufficient to be raked ed in heaps: this is called *bay-salt*.

al parts of France, and on the coast of China, the sands of the sea-washed, and the brine thus obtained is subsequently evaporated in various places of Germany and France, the salt waters are pumped

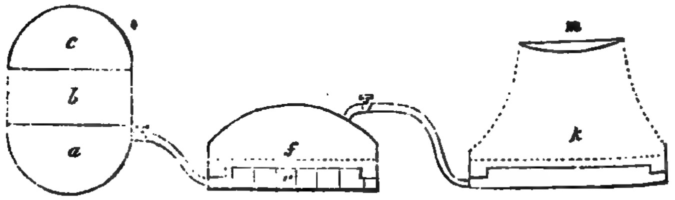
up to the top of very extensive sheds, filled with brushwood, over which it is duly distributed by means of gutters, whence, falling in drops from sprig to sprig, a rapid evaporation takes place over an immense surface; the same water is pumped up many times before it is sufficiently concentrated to be drawn off into boilers, which complete the operation. See an account of several works of this kind in Dr. Ure's Dictionary of Chemistry.

Under the article Evaporation, we have given several ingenious illustrations of the process of "Salt-making." In this place we shall add a notice of two or three more recent inventions.

Messrs. Jump and Coart's patent method consists in concentrating the salt water, by a simple arrangement, previous to its entering the pans. For this purpose, the reservoir of salt water is elevated above the pans, and the pipe which supplies them with the brine first passes through all the furnaces beneath, which brings the liquid quickly to a boiling temperature, in which state it is discharged, by means of a curved pipe, into the pans above, thereby greatly facilitating and abridging the process of concentration. A stop-cock is placed in the supply-pipe, so that, as often as it is desired to replenish the pan, this cock is opened, and the superincumbent pressure of the water in the reservoir forces out the boiling brine from the pipe into the pan, the pipe receiving, in lieu thereof, the cold liquid from the reservoir.

Mr. Johnson, of Droitwich, according to his patent of 1827, employs steam of different degrees of heat to produce the evaporation in pans closed from the atmosphere, so that the vapour arising from the first pan, where the *fine* salt is produced, is employed in heating the second, where the *broad salt* is formed: and the vapour arising from the latter is employed in like manner, to produce in the third pan British bay-salt.

A sketch of the steam boiler is represented in the annexed drawing, divided into three portions, *a*, *b*, and *c*; and steam is generated in one or more of



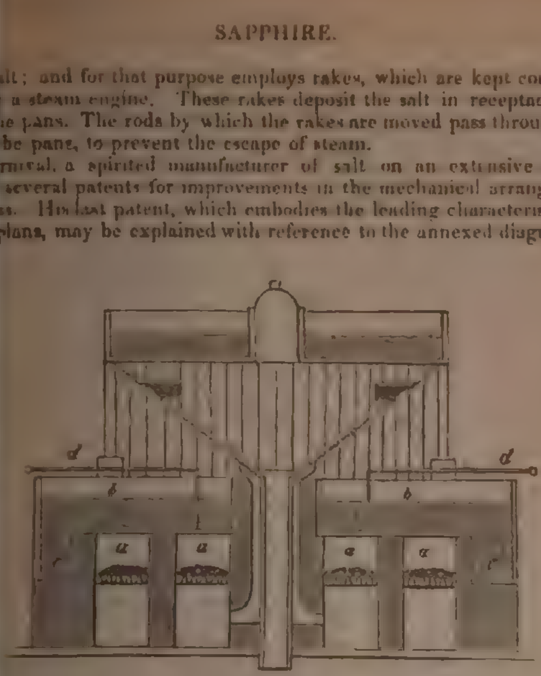
these divisions, according to the supply required. When the steam in *a* is raised to a pressure of twenty-five pounds on the square inch, that in *b* will be twelve, and that in *c* five pounds. When only one of the divisions, *a*, of a steam-boiler about seventeen feet by ten is employed, it will heat pans to the extent of 2,400 square feet up to 164° Fahr.; and when the three divisions, *a*, *b*, and *c*, are used together, an extent of 4,300 square feet will be heated to the same temperature.

The steam is conveyed in a pipe from the boiler to a steam-vessel *e*, under the fine salt-pan *f*. This pan is made steam-tight, and the steam arising therein is conveyed by a pipe to a similar vessel under the broad salt-pan *k*. Over the broad salt-pan *k* is placed the bay salt-pan *m*, and the space between them is enclosed by thin boards, or other light material, to confine the vapour arising from *k*, in order to produce the required heat in the pan *m*. This pan is made lowest in the middle, as represented in the drawing, so that water condensed on its lowest surface may be collected in one place, where it is received and carried off in a spout, to prevent its return into the brine in the lower pan *k*.

The patentee considers it of great importance to keep the bottom of the pan

salt; and for that purpose employs rakes, which are kept constantly in by a steam engine. These rakes deposit the salt in receptacles at the the pans. The rods by which the rakes are moved pass through stuffing the pans, to prevent the escape of steam.

Furnival, a spirited manufacturer of salt on an extensive scale, has several patents for improvements in the mechanical arrangements of cess. His last patent, which embodies the leading characteristics of his plans, may be explained with reference to the annexed diagram, which



sents a vertical section of the apparatus, with two tiers of pans. *a a a a* furnaces, the flues from which are extended under a considerable range ce of the pans, which are of the shape represented at *b c*, the deep part made to receive the salt thrown over by the ebullition, and also such as may be scraped from the surface of *b*, by means of the instruments *d d*. The deep chambers being removed from the direct action of the vent the salt deposited therein from becoming burned; and these recep-being at the sides, the salt is conveniently scooped out. The steam from the lower range of pans is then employed to heat an upper range less area, supported upon suitable framing, lined interiorly, to confine with boards. In order that the water resulting from the condensation steam against the bottoms of the upper pans, may not fall back into the pans, two inclined planes are formed, which receive the condensed water, duct it into a pipe, whence it is carried off by a gutter underneath. In inclined planes suitable apertures are made for the passage of the ascend-from the lower to the upper boilers.

patentee also proposes to heat a third set of pans above the second: for pose there is a central aperture to conduct the steam to them; this is covered with a cap.

PHIRE. A precious stone, of which there are several varieties; next mond, it is considered the most valuable of gems. The white and pale eties, by exposure to heat, become snow white, and, when cut, exhibit a degree of lustre, that they are used in place of diamond. The most prized varieties are the crimson and carmine red; these are the oriental the jeweller; the next is *sapphire;* and last, the yellow, or oriental The asterias, or star stone, is a very beautiful variety, of which the generally violet-red, and the form a rhomboid, with truncated apices, exhibit an opalescent lustre. A sapphire of ten carats' weight is con-to be worth fifty guineas. An *oriental ruby* of thirty carats, without and of a perfect colour, is considered almost as valuable as a diamond of weight.

SARDONYX. A precious stone, consisting of a mixture of chalcedony and cornelian, sometimes in strata, but at other times blended together. It is found, first, striped with white and red strata, which may be cut in cameo as well as the onyx. Second; white, with red dentritical figures, much resembling the mocha-stone, excepting that the figures in the latter are of a black colour, instead of a red. There is no real difference, except in the circumstance of hardness, between the onyx, cornelian, chalcedony, sardonyx, and agate, notwithstanding the different names bestowed upon them. This stone was formerly much employed for the sculpture of cameos.

SARSAPARILLA. A medicinal root, obtained from Peru: it consists of a great number of long strings, hanging from one head; they are given in decoction, as a diet drink.

SASSAFRAS. The wood of an American tree, of the laurel kind, imported in large straight blocks; it is said to be "warm, aperient, and corroborant," and to be often successfully employed in purifying the blood, for which purpose an infusion, in the way of tea, is a very pleasant drink; its oil is fragrant, and possesses most of the virtues of the wood.

SATIN. A kind of silken stuff, very smooth and shining. The woof is coarse, and hidden underneath the warp, which is fine, and stands out, and on this depends its gloss and beauty.

SATURATION. The act of imbibing till no more can be received. A fluid that holds in solution as much of any substance as it can dissolve, is said to be saturated with it. But saturation with one substance does not deprive the fluid of its power of acting on, and dissolving some other bodies, and in many cases it increases this power. For example, water saturated with common salt will dissolve sugar; and water saturated with carbonic acid will dissolve iron, though without this addition its action on this metal is scarcely perceptible. The word saturation is likewise used in another sense by chemists: the union of two principles produces a body, the properties of which differ from those of its component parts, but resemble those of the predominating principle. When the principles are in such proportion that neither predominates, they are said to be saturated with each other; but, if otherwise, the more predominant principle is said to be sub-saturated, or under-saturated, and the other supersaturated, or over-saturated.

SAWS, AND SAW-MILLS. A saw is a cutting instrument, with a serrated edge; a saw-mill, a machine or building, wherein several or many of these instruments are actuated by horse, wind, steam, water, or other power.

It was not until the seventeenth century that saw-mills were introduced into England, attended with the most violent opposition from the sawyers, who apprehended they would be the means of depriving them of their subsistence. Some that were undertaken were abandoned at the outset, and others were destroyed by the populace.

The saw-mills of the present day are of two distinct kinds; the *circular*, those that cut by a continuous rotatory motion, and the *reciprocating*, which operate as the common pit or frame-saw. The *circular saw-mills* are for the most part used for cutting up timber of small dimensions; and the *reciprocating* for large timber, in forming beams, rafters, planks, &c., out of large timber. The most important machinery of the kind was erected by Mr. Brunel, at Portsmouth, to whom the mechanical world is indebted for many important inventions and improvements.

Saws are made of a great variety of forms and sizes, to adapt them to the materials on which they are designed to operate. The most common are those used by carpenters, who require in ordinary no less than ten different saws, namely, a *cross-cut* saw, for dividing a tree or log transversely, by means of two workmen, one on each side, who alternately pull the saw towards them, the teeth being made to cut equally in each direction; a *pit-saw*, for sawing the logs up into planks or scantlings, the operation being performed in a pit by a vertical motion of the saw, and usually by a class of workmen called sawyers; a large *frame-saw*, which is a saw-plate five, six, or seven feet long, stretched in a frame, and used to cut timber longitudinally with greater nicety than the

saw, a *ripping-saw*, which is a hand-saw, with a blade twenty-eight or ty inches long, and having large teeth for ripping, or cutting out stuff rsely and quickly; a *hand-saw* (peculiarly so denominated), usually provided h a twenty-six inch blade, and angular teeth, five to the inch; a *panel-saw* he same as the hand-saw, but with finer teeth, (seven or eight to the inch,) cutting stuff very clean, and for the more delicate or exact species of work. s with very fine teeth, and very thin blades, stiffened with stout pieces of or brass, riveted to the back edge, are also used, of several kinds, which distinguished by the several terms, *dovetail*, *sash*, *carcase*, and *tenon*, indive of their uses, and also of their sizes, which vary from six to twenty inches length; several very narrow saws, indifferently called *lock*, *compass*, *key-hole*, d *turning* saws, for cutting out small pieces, and rounding work: small *w-saws*, six or eight inches long, are sometimes required by the carpenter cutting both wood and iron; the teeth of the latter being smaller and more ne than the former. There are many saws used by other mechanics, which er from the carpenter's, the details of which would be uninteresting, we ll therefore proceed to take a brief notice of the process of manufacturing , as practised at Sheffield, from whence three-fourths of the inhabitants of globe are supplied.

The very commonest kind of saws are made of iron plates, hammer-harned, and planished upon an anvil, to give them some degree of stiffness and ticity. Such instruments are, of course, spurned by the workmen; neverless, as their cost is but trifling, they are purchased in great quantities by e who consider any saw to be better than no saw at all.

The more useful saws which workmen employ are made, nominally, of either r or *cast* steel; but the quality of these materials may differ, as well as the made of them, in every possible degree. The common test of a good saw, t of bending it into a bow, and letting it spring again into a straight line, is dered by some persons as a fallacious and unnecessary test, and that it etimes spoils a saw, possessing in other respects all the properties of a able tool. A dispute has been raised on this point, and ably advocated on h sides. For our own parts, we would simply observe, that such process of nging infallibly proves *two* of the essential properties of a good saw, namely, formity of thickness in the blade, and perfect elasticity.

Experience has shown that cast steel is the best material for making saws, as l as most other tools, on account of the greater uniformity of its structure, ich is not lost by the subsequent operations of rendering it malleable and r. To prepare this material, the liquid metal is poured into a cast-iron ld, out of which the casting, when cooled, is taken, in the form of a small about 1½ inch thick. This slab is next laminated between rollers until it extended to the required dimensions. If intended for the larger kind of as mill or pit-saws, the whole piece may be required, in which case it is ped by shears to the required shape; but if for smaller articles, it is cut up suitable pieces; the edges are next perfected by filing, and holding the flat of the plates against large grindstones, which process prepares them for the ng of the teeth. This operation is usually performed by a die-cutter in a ress, the motion of the saw-plate being duly regulated, so that the teeth l be uniform; the large teeth being cut one at a time; and the smaller, two, e, or more at a time, according to circumstances. The wire edges left on teeth of the plates by the cutting-out press, are next removed by filing. e operations of hardening and tempering succeed, which require considerable and attention on the part of the operator. A variety of fatty compositions e been recommended for this purpose, as possessing peculiar efficacy in dening, amongst which we may instance that recommended by Mr. Gill, appears to have had considerable experience in matters of the kind, and to somewhat acquainted with chemical science; we should, otherwise, have en an exception to the variety of similar ingredients in his caldron. He es us to melt together 3lbs. of black rosin and 1lb. of pitch, and to these en melted) one gallon of neatsfoot oil, 20lbs. of beef suet, rendered, and gallons of olive oil. All these are to be heated together in an iron

vessel until the aqueous vapour is driven off, and the composition will take fire by the application of flame to the surface, which is then to be extinguished by placing on the cover of the vessel. The saw-plates being now heated in a reverberating or other suitable furnace to a cherry red, are precipitated edgewise into the liquid mixture just mentioned, contained in a vessel of a proper figure for that purpose, and when sufficiently cooled therein to be handled, they are taken out and are found to be extremely hard and brittle. The unctuous matter which adheres to the plates being next partially removed, they are taken up successively by a pair of tongs, and passed backwards and forwards over a clear charcoal fire, so as to cause the unctuous matter to inflame, or "blaze off," as it is termed, which reduces the saws to the desired temper; and whilst the saw-plates remain hot, any warping they may have acquired in the process is removed by smart blows from a hammer, over an anvil strewed with sand, to prevent the article from slipping about.

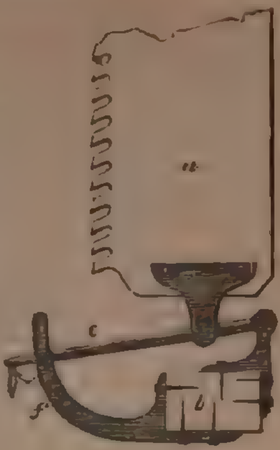
The next operation is planishing by hammers, which renders them more even and equally elastic; and the dexterity and care with which this operation (so difficult and tedious to ordinary smiths) is performed, is a remarkable instance of what human art is capable of by long practice.

The saws are now ready for the grinder, who applies them to the circular face of a large grindstone, by an interposing board, against which be presses with all his force, so as to grind it as evenly as possible. Standing on tip-toes, he stretches himself over a large grindstone, which is revolving with great rapidity; his hands, arms, breast, and knees, being all brought into operation to produce the effect, while he becomes covered with ochrous sludge, formed by the attrition against the stone; an operation apparently so dangerous and disagreeable, as to give pain to the spectator, and make him wish to see a machine supplying the place of the operator.

The grinding of the saw-plates materially impairs their previous flatness and elasticity; they are, therefore, submitted to a second hammering by the planishers, and are afterwards heated over a coke fire until they attain a faint straw colour, which restores to them their elasticity. The surfaces are next lightly passed over a grindstone, to remove the appearances of the hammer, and next over a fine hard stone, to remove the scratches of the last, and give it the kind of polish required in the market for which the saws are intended. For which purpose the glazing wheel of buff leather and emery, or the "hard head," which is a wheel of hard wood, worked bare, are also used, as occasion may require. To correct any defects that the saws may have acquired during the processes described, they are next "blocked," that is, struck upon a post of hard wood, by means of a small polished hammer, by which the truth of the work is presumed to be perfected.

The saws are next "cleaned off" by women, by means of fine emery rubbed over them lengthways by a piece of cork-wood, which gives them an agreeable, even, white tint, and a very level appearance. They are next handed to the setter, who places each alternate tooth over the edge of a little anvil, in an angular direction, and strikes them so as to bend each uniformly into the required deviation from the plane of the saw; then turning over the saw, the setter strikes, in like manner, the alternate teeth, which he left untouched on the other side; in this manner each successive tooth is placed in opposite directions, at the desired *set*, to allow the blade of the saw to pass through the wood without resistance, while its breadth acts as a guide, and serves to give stability and effect to the operation of sawing. The teeth of the saw are again touched up with a file, to finish their sharpening; for which purpose they are fixed between two plates of lead, contained in the chaps of a vice; after which their handles are fixed by nuts and screws, cleaned off, oiled, and packed in brown paper, for sale.

The form or mode of construction of the saws we have described, has been generally found so efficient and useful, as to have needed no material improvements; we shall, therefore, simply notice, in a brief manner, two or three matters of a subordinate character, connected with the subject, which may prove of service to the workman.



-saw, it is well known, can be ..ier than a common pit-saw; ..orks in a smaller kerf, it would ..siderable saving of timber if it ..mployed in lieu of the pit-saw ..logs up into thin boards. To ..object, an ingenious shipwright ..ithe contrived the arrangement ..d in the subjoined cut. *a* is the ..of a frame-saw; *b* a section of ..bar of the frame; *c* the holdfast; ..o pins; *e* the lever; *f* a double ..ed with holes, the lever work..en the two parts of the arch; ..can be held to any degree of ..by a small peg, fastened by a ..he end of the lever. To shift ..ess the lever, take out the peg, ..lever, take out the two pins *d d*, ..w being lifted, and swung back, ..ut in the next cut, and again

..ting with a common frame-saw, it would be necessary, at every ..cut, to shift all the transoms behind the saw to the end of the piece, ..d be necessary to take the saw out of the frame, when a difficulty ..e of fixing it again tightly. Both these objections are obviated by ..e have described; and by which, long deals, planks, and boards, may ..h an important saving of material.

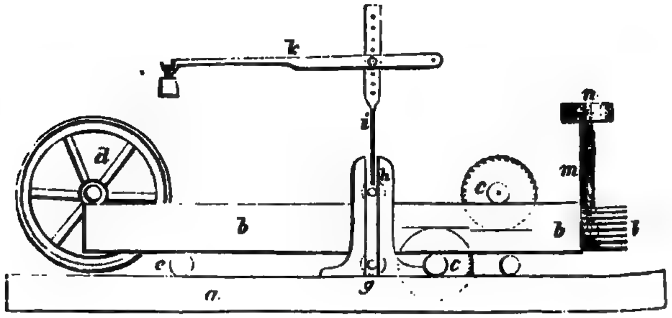
..anding wedge for the use of ..represented in the subjoined ..as invented by Mr. T. Griffiths, ..yal Institution, and was deemed ..f an honorary medal from the .. Arts. *a* is the handle or cen..o which is connected two springs ..d together at *b*; the handle also ..ross piece *d*. This instrument is ..o save the time and trouble of ..e common wedges, while sawing ..f fir into deals. When the saw ..o or three feet, the loose ends of the springs *c c* are to be brought by ..ar to the centre piece *a* as their elasticity will admit; the end *b* is ..e introduced into the cut, and the wedge is to be thrust up to the ..e spring, the cross piece *d* resting on the upper surface of the balk. ..city of the springs will then be continually opening the cut as the ..ds, to the length of about twelve feet; and the wedge, when at its ..pansion, will be prevented, by the cross piece, from falling into the pit.

..rdinary saw-mill, the saws are stretched in a wooden frame, which ..and down within another frame, in a similar manner to a window .. motion is given to it by a crank, attached to a fly-wheel upon the .., made to revolve by a water-wheel, or other power, and connected ..at will give four or five revolutions of the crank to one of the water ..The timber is fastened upon a carriage, which is a horizontal frame, ..olling between guides on the floor of the mill, and of such dimensions ..between the vertical frame, proceeding by a regulated motion, and ..presenting the timber to the action of the saws. The saws are so ..e frame that they can be removed in a few minutes, and replaced by ..of sharpened saws.

..rable improvements have been made upon saw-mills by Mr. Brunel, ..dslay, and many other engineers, who have, of late years, been

engaged in their construction. The introduction of circular saws, which act b a continual rotary motion, formed an important era in sawing machinery, fro the great facility, precision, and rapidity of its operation. A saw-mill of th kind has been employed for many years at the manufactory of the ingeniou Mr. George Smart, near Westminster Bridge. In this, motion is imparted to horizontal shaft, on which is a spur-wheel that turns a pinion on another ho zontal shaft; on this second shaft, the bearings of the gudgeons of which a supported on the joists of the floor above, is a band-wheel, which communicat motion, by an endless strap, to a pulley fixed on the spindle of the circular sa and causes the latter to revolve with great rapidity. The ends of the spind are conically pointed, and the end nearest to the saw turns in a cavity made i the end of a screw, whose nut is fixed, and has a firm bearing in a stout bench the other end turns in a similar screw, passed through a cross beam, mortis between two vertical beams, extending from the floor to the ceiling; one of th beams can be raised or lowered in its mortises by wedges put both above a below its tenons. In order to adjust the plane of the saw to the plane of t bench, there is a long parallel ruler, which can be set at any distance from t saw, and fixed by means of screws going through circular grooves cut throu the bench. In using the machine, the ruler is to be set the proper distan from the saw, according to the piece of wood to be cut; and as the saw tu round, a workman slides the end of a piece of wood to it, keeping its ed against the guide or ruler, that it may cut straight. The operation is, of cour very expeditious and accurate. Lathes are now frequently fitted up wi circular saws.

Some improvements in mechanism of the latter kind were patented b Messrs. Sayner and Greenwood, in 1824, which we shall here describe. Th first improvement mentioned in the specification relates to the adaptation two circular saws operating together, instead of one, to cut through a piece timber. By the usual process, it requires a circular saw of five feet in diamet to cut through a log of two feet in diameter, in consequence of the obstructi of the axis and supporting shoulders; but by the application of two saws little more than half the diameter of the single large saw, one above the lo and the other under, each making an incision rather more than half wa through, the division is effected with a considerable saving of power, and the cost of saws. The annexed diagram is designed to explain the mechani



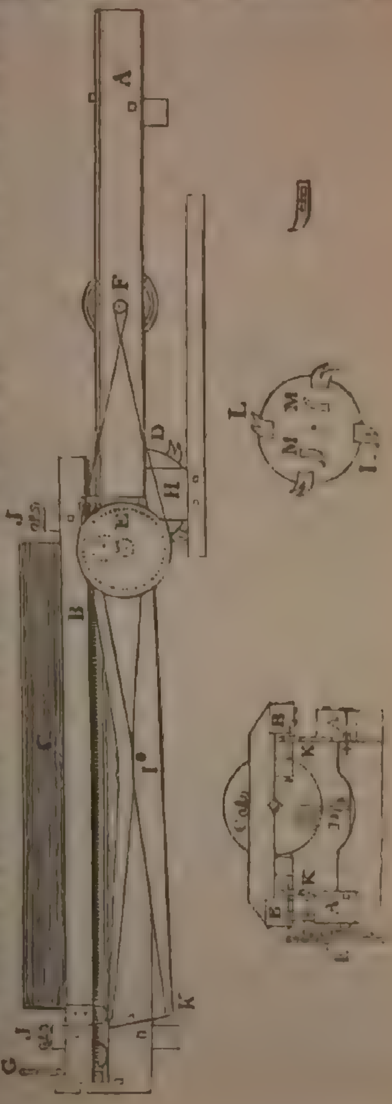
arrangement. *a a* is the bed of the saw-mill; *b b* the log of timber und operation; *c c* the two circular saws, the depths of their respective cuts bei expressed by two right lines forming tangents to their peripheries; these sa have pulleys upon their axes, and are driven by endless bands embracing th and the drum-wheel *d*, to which motion is given by a water-wheel, or oth adequate mechanical agency. The timber rests and moves upon horizon

...nd is accurately guided to the saws by vertical rollers, not intro- ...he figure, as they are common to other saw-mills The axes of the ... fixed bearings, and the timber is forced against them by the revo- ... propelling roller *g*, put in motion by another band from the drum- ... axis of the roller being confined by an upright frame *g h*; in the ...f which frame turns the pressing roller *h*, which being connected ...l bar *i*, is pressed upon by the weighted lever *k*; the roller *g* there- ... motion, and the roller *h* a steady firmness to the advancing posi- ... log.

...mber is to be cut into planks, a number of circular saws are placed ... the axes *c c*, with flanges between them of the thickness of the ...nks, and then bolted ... by these means the ... is at one operation ... boards; and if it be ...cut the logs into scant- ..., a series of horizontal ...d in like manner upon a ... *m*, and driven by a ...nts the whole at once ...mall divisions. This ...plying the saws to work ...al plane so as to oper- ...neously with those act- ...rtical direction, forms ... improvement claimed ...atent right.

...mprovement claimed, ... the plates of a series ...saws closely together, ...e one compact body of ...out any interstices ...m, for the purpose of ...ye-woods entirely to ...powder, instead of the ...hod of chipping or ... for dyeing or other ...

...ars ago (about 1824), ... Eastman, of Bruns- ..., U. S., invented some ...ts in the construction ...saws, and in the mode ... lumber " (timber), ...ned extensive adoption ... and as we think them ...teresting, and that their ... this country would ...ficial results, we shall ... the description, and ...nt inventor's remarks ...ubject. Instead of a ...ries of teeth all round ...y of the plate, like ... saws, Mr. Eastman's ...lt, or rather it may ...ave only four cutting ... each containing two ... are placed at equal ... the circumference,



and projecting from it; these instruments are called "section teeth." The saving of labour in consequence of this form of saw is calculated at full three-fourths; and the surface of the timber is much smoother than when cut by the full-teethed saw. On the saw-plate are also fixed instruments called "sappers," which, being placed nearer to the centre, do not enter the wood so deeply as the saw, and are adjusted so as merely to cut off the extraneous sap part, rendering the edges of the planks uniformly straight, and all the cuts of equal dimensions. To understand which, it is, perhaps, necessary here to explain to the reader that the logs are, by this machinery, cut up lengthwise, *not through the log*, but from the circumference, or exterior, to the centre, as the radii of a circle, it having been ascertained that planks, staves of casks, &c., cut out in this manner, possess much more durability, strength, and elasticity, than by the common method. *Fig.* 1 represents a side view of the machine, with a log in it ready for working. *Fig.* 2 is an end view of the same, exhibiting the log partly cut into sections. *Fig.* 3 is the saw, with its section teeth L L L L, and its sappers M M. *Fig.* 4 shows the shape of the sapper, with a groove, or slit, to admit of its being set according to the intended width of the plank.

A, *Fig.* 1, is a strong frame of timber, about twenty-four feet long, by five broad, the ends of which are seen at A A, *Fig.* 2. B, *Fig.* 1, is the carriage, about twelve feet long, and four broad, the ends of which are seen at B B, *Fig.* 2; it travels upon iron truck-wheels, grooved on their circumferences, and run upon iron slides, as shown at K K, *Fig.* 2. C. *Figs.* 1 and 2, gives two views of the log under operation.

The log is fixed into the carriage by means of iron centres, upon which it also revolves, after each succeeding cut. At D D, *Figs.* 1 and 2, is seen part of the saw. At E E, *Figs.* 1 and 2, are situated the feed pulley, and shifting gear F, regulating pulleys. G is an index for regulating the dimensions of the cuts. H, revolving levers and pins. I, the pin and fulcrum of the levers. J J, the stirrup screws and pins.

Nearly in the middle of the frame is fixed the *main shaft*, of cast iron, which runs upon friction rollers, supported by stands on the floor. On this shaft is the saw, with its sappers and section-teeth. The motion is given by a band passing round the main pulley, and round a drum that runs under it; which may be driven by horse, steam,* or water power. The method by which the saw is fed with the wood to be cut, and the return of the carriage for the succeeding cut, is too similar to our own to need a particular description. Its various arrangements are ingeniously contrived, and it may be justly termed a self-acting machine, for when once set in motion, no other aid than the power which drives it is requisite to its cutting a whole series of boards, of uniform dimensions, all round the log, having their thin-edged sides attached to the centre-piece. These boards being removed, a second series of boards may be cut in like manner to the former, provided the log is big enough.

"This machine," Mr. Eastman says, "furnishes a new method of manufacturing lumber for various useful purposes. Though the circular saw had previously been in operation in this country, and in Europe, for cutting small stuff, it had not, with the knowledge of the writer, been successfully applied to solids of great depth; to effect which, the use of section-teeth are almost indispensable.

"In my first attempts to employ the circular saw, for the purpose of manufacturing clap boards, I used one nearly full of teeth, for cutting five or six in depth, into fine logs. The operation required a degree of power almost impossible to be obtained with the use of a band; the heat caused the plate to expand, and the saw to warp, or, as it is termed, 'get out of true.' To obviate these difficulties, I had recourse to the use of section-teeth, and the improvement completely succeeded. The power required to perform a given quantity of work by the former method, was by this diminished at least three quarters. The work, formerly performed by seventy or eighty teeth, was, by the last method, performed by eight teeth; the saw-dust, which before had been reduced to the fineness of meal, was coarser, but the surface of the lumber much smoother than when cut with the full-teethed saw. The teeth are made in the

form of a hawk's bill, and cut the log up, or from the circumference to the centre. The saw may be carried by an eight-inch band, and when driven a proper speed (which is from ten to twelve hundred times per minute) will cut nine or ten inches in depth into the hardest white oak timber with the greatest ease. The sappers, at the same time, cut off from one to two inches of the sap, and straighten the thick edges of the lumber.

"The facility with which this saw will cut into such hard materials, may be supposed to result from the well-established principle, that where two substances in motion come in contact, their respective action on each other is in direct proportion to their respective velocities; thus, a circular plate of iron put into a quick rotary motion, will, with great ease, penetrate hardened steel, or cut through a file when applied to its circumference; and the same principle is applicable to a saw for cutting wood. The requisite degree of velocity is obtained by the continuous motion of the circular saw, by which also it has greatly the advantage of one that has but a slow motion, on account of dulling; as the teeth are but little affected, and being only eight in number, but a few moments' labour is required to sharpen them. If the velocity of the saw were slackened to a speed of but forty or fifty per minute, it would require at least four such bands to carry it through a log as above described.

One machine will cut from eighteen to twenty hundred of square feet of pine timber per day, and two of them may be driven by a common tub-wheel, seven or eight feet in diameter, having six or seven feet head of water, with a cog-wheel and trundle-head, so highly geared as to give a quick motion to the drums, which should be about four feet in diameter. The machine is so constructed, as to manufacture lumber from four to ten feet in length, and from two to ten inches in width, and of any thickness. It has been introduced into most of the New England states, and has given perfect satisfaction. The superiority of the lumber has, for three years past, been sufficiently proved in this town, (Brunswick Maine,) where there have been annually erected from fifteen to twenty wooden buildings, and for covering the walls of which this kind has been almost universally used. The principal cause of its superiority to mill-sawed lumber, is in the manner in which it is manufactured, viz., in being cut towards the centre of the log, like the radii of a circle; this leaves the lumber feather-edged in the exact shape in which it should be, to set close on a building, and is the only way of the grain in which weather-boards of any kind can be manufactured to withstand the influence of the weather, without shrinking, swelling, or warping off the building. Staves, and heading also, must be rived the same way of the grain, in order to pass inspection. The mill-sawed lumber, which, I believe, is now universally used in the middle and southern states, and in the West Indies, for covering the walls of wooden buildings, is partly cut in a wrong direction of the grain, which is the cause of its cracking and warping off, and of the early decay of the buildings, by the admission of moisture. That such is the operation, may be inferred, by examining a stick of timber, which has been exposed to the weather; the cracks caused by its shrinking all tend towards the heart or centre, which proves that the shrinking is directly the other way of the grain. It follows, that lumber, cut through or across the cracks, would not stand the weather in a sound state, in any degree to be compared with that which is cut in the same direction with them. I have no hesitation in stating that one-half the quantity of lumber manufactured in this way, will cover, and keep tight and sound, the same number of buildings for a hundred years, that is now used and consumed in fifty years. Add to this, the reduction of expense in transportation, and of labour in putting it on, and I think every one must be convinced that the lumber manufactured in this improved way is entitled to the preference.

"In manufacturing staves and heading, a great saving is made in the timber, particularly as to heading, of which at least double the quantity may be obtained by this mode of sawing to what can be procured in the old method of riving it, nor is the straight grained or good rift indispensable for the saw, as it is for the purpose of being rived. The heading, when sawed, is in the form it should be, before it is rounded and dowelled together, all the dressing required being

merely to smooth off the outsides with a plane. Timber for staves ought to be straight, in order to truss, but may be manufactured so exact in size, as to require but little labour to fit them for setting up. Both articles are much lighter for transportation, being nearly divested of superfluous timber, and may be cut to any thickness required, for either pipes, hogsheads, or flour barrels."

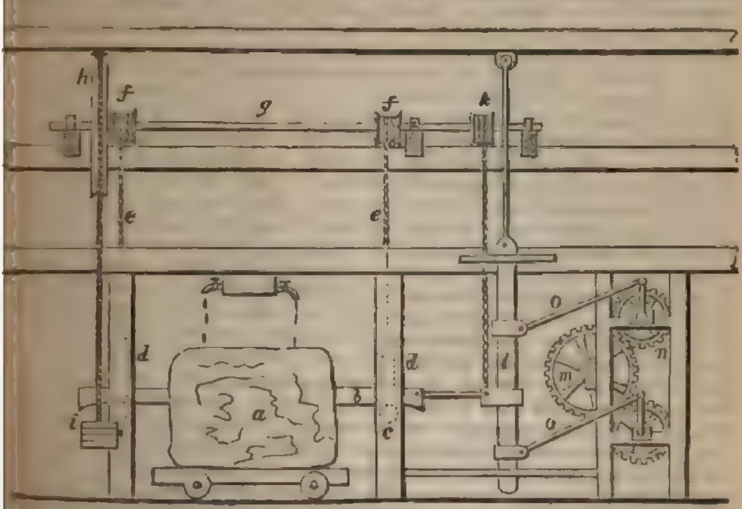
Mr. Alexander Craig, of St. Bernard's, in the county of Mid-Lothian, obtained a patent, in 1831, for "certain improvements in machines or machinery for cutting timber into veneers or other useful forms." In one of these improvements, Mr. Craig employs a circular saw, which he makes to traverse the whole length of the veneer to be cut, while it revolves on its axis in the usual way. It is made to traverse by means of a crank, having a radius equal to half the length of the intended veneer, and a connecting-rod, of length sufficient to prevent too much obliquity of action. A uniform tension is preserved on the band which communicates motion to the saw while it approaches to, and recedes from, the source of motion, by carrying the band round a pulley stationed at a small distance beyond the greatest distance of the saw from its driving drum. Though we have mentioned but one saw, there are a series of them attached to the same frame, and put in motion by the same band, which is pressed down by an adjusting pulley between each pair of saws, that it may turn them with more certainty, by embracing a larger portion of the circumference of the riggers fixed on their axes. The log of wood from which the veneer is to be cut is suspended between centres, similar to those of a turning-lathe, and made to rotate in contact with the saws, so that it may be cut into one continuous spiral veneer. It is evident, that to produce a uniform motion in that part of the log in contact with the saws, is necessary to its perfect action; and this the patentee has effected in a very ingenious manner: he puts into slow motion, by a species of gearing known by the name of the endless screw, a shaft, having on its extremity a metallic cylinder, with a surface roughed in a manner similar to the surface of a rasp; and this cylinder, being pressed against the circumference of the log, will cause it to revolve at the same speed, whatever be its diameter. The specification is concluded by a description of an arrangement by which the saws are made to cut beyond their centres in a stationary log. This is effected by attaching them on axes which do not project beyond the surfaces next the log. To the frame carrying these saws, a descending as well as an alternating motion is given; and the veneer being, by a guide-plate, made to fold back under the saws, it is clear that they will with facility cut to any required depth, without reference to their diameters. See the article Veneer.

The sawing of stone, as our readers cannot fail to have noticed, is an extremely slow operation, and no improvement of importance has been effected in the process for many centuries; the ancient mode of causing a plate of iron stretched out in a frame, to reciprocate horizontally by the two hands of the sawyer, seated before it, is still generally practised. In dividing very soft stone, the saw itself acts with efficacy upon the stone, by means of its small rude teeth, or notches, which the sawyer makes in its edge by striking it with a coarse tool: but the chief utility of these notches is to collect and apply the particles of sharp sand that are carried by a small current of water down into the incision, and under the saw. In hard stone, almost the whole effect of cutting is produced by the attrition of the sand, aided by the pressure of the weight of the saw.

In 1825, a patent was taken out by Mr. James Tullock, for "improved machinery for sawing stone," in which, however, the same principle of cutting is still adhered to; but the general arrangements of his stone-sawing-mill are judicious for the application of *power*; we therefore annex a description, with an illustrative cut.

A block of stone is shown at *a*, supposed to be under the operation of a number of saws *b*, fixed parallel to each other in a frame. The ends of this frame are formed on the under side into inclined planes, which run upon two anti-friction rollers at *c c*; so that when motion is given to the saws, each end of the frame will be alternately lifted up, and allow the sand and water (supplied

y a small cistern represented) to descend into the fissure. The anti-friction rollers are attached to two slides, placed in grooves, in the two upright posts *d d*, and are suspended by two chains *e e*, wound round the barrels *f f*, on the



shaft *g*: this shaft turns in the bearings shown, and carries a third barrel *k* and a large pulley *h*; to the latter is suspended a weight which partly counterbalances the weight of the saws and frame; and a chain, passing round the barrel *k*, is attached at the other end to a sliding piece, on a vibrating beam *l*. The gear represented on the right hand of the engraving is for giving motion to the saw-frame. The power of a first mover being applied to the toothed wheel *m*, it actuates the two smaller wheels *n n*, to the shafts of which are fixed cranks, which as they revolve give motion, by means of the connecting-rods *o o*, to the vibrating beam *l*, and the latter gives the alternating motion to the saw-frame *b*. The several pulleys to which the frame is suspended admit of its regular descent, and with a uniform pressure. The weight of the saws should of course always predominate over the counterbalance, that they may act effectively upon the stone.

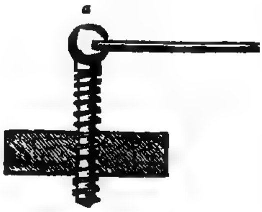
It appears from the specification, that the patentee applies this mechanism in the forming of grooves, mouldings, cornices, pilasters, &c., of marble and other stone, by means of properly-indented instruments, which are to traverse the face of the stone, suspended in a suitable frame. By suspending the saws or tools in the manner described, it is considered that a great advantage is gained, as they may thereby be kept in a perfectly horizontal line, so that the face of the stone may be acted upon uniformly in all its parts, and the hardest parts be reduced equally with the softest.

SCALE. A mathematical instrument, consisting of various lines drawn on wood, ivory, brass, &c., and variously divided, according to the purposes it is intended to serve; whence it acquires various denominations, as the plain scale, diagonal scale, plotting scale, Gunter's scale, &c. Scales of equal parts, marked upon plans, drawings, &c., are explanatory of the real dimensions of the objects delineated, instead of their actual dimensions on the paper.

SCALES. A term commonly applied to the ordinary balance or weighing machine, which see. The term scales, however, is often applied to the boards or dishes only, in which the goods and the weights are placed.

SCALES OF FISH consist of alternate layers of membrane and phosphate of lime; they are employed in the arts in the fabrication of artificial pearls. See PEARLS.

SCREW. The screw is one of the most powerful and useful of the machines or mechanic powers. It is a modification of the inclined p will easily appear to any one who reflects a little on its constructio triangular piece of paper be rolled round a cylinder, it will form inclined line round it, which will be not an inapt representation of the of the screw. The screw with the projecting thread moves within a spiral groove cut in the interior of a hollow cylinder, which is ter female screw or nut. The screw is generally turned by means of a lever, as represented in the annexed cut at *a b*; and the power obtained by the instrument is calculated by dividing the circumference of the circle described by *a b* by the distance between two successive threads of the screw. Thus, if the lever *a b* be thirty inches long, and the distance between two threads of the screw be half an inch, the circumference described will be 94 inches;



which, divided by half an inch, gives 118 as the increase of power obt this machine. In this case, a man who could exert a force of 100lbs. v enabled to produce a pressure equal to that of 18,800 lbs. Fro remarks it will be seen that there are two ways of increasing the powe machine; viz. by lengthening the lever *a b*, or by diminishing the between the threads. The former would be limited by the unw thereby given to the machine; and the latter, by the circumstance threads become weaker in proportion as they are diminished, and henc resistance would tear them from the cylinder. These inconvenie obviated in a contrivance of Mr. Hunter's, in which the required stre compactness may be carried to any extent. This contrivance consist use of two screws, the threads of which may have any given stren which differ slightly in breadth. While the working point is urged for that screw whose threads have the greater breadth, it is drawn back whose threads have the less; so that, during each revolution of th instead of being advanced through a space equal to the breadth of eith threads, it moves through a space equal to their difference. The powe a screw will be equal to that of a single screw, the distance betwe threads is equal to the difference of the distances between the thr mentioned.

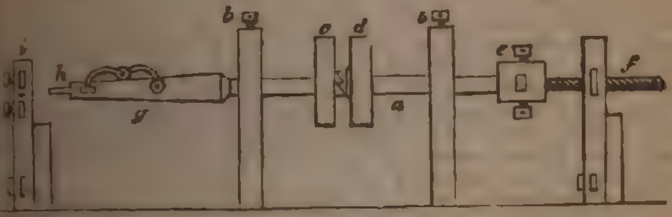
The great power and compactness of the screw, as a mechanica render it highly useful in the formation of presses, in which a great is required. The screw is therefore usually employed in the expr juices from solid bodies, in coining, and in reducing the bulk of light bodies, so as to render them convenient for exportation. (See Press.)

The screw is also used very efficiently in the measurement of ver motions and spaces. Thus, suppose the screw to have one hundred t the length of an inch, each revolution of the screw will advance the p hundredth of an inch. Now, if the head of the screw be a circle on diameter, the circumference of the head will be somewhat more than thre this may be easily divided into a hundred equal parts, each distinctly a fixed index be used, the hundredth part of the revolution of the sc be observed, and this will advance the point of the screw one ten-th of an inch. To observe the motion of the point of the screw, a fin attached to it, which is carried across the field of view of a powerful mi by which its motion is made distinctly perceptible. Such a screw is micrometer screw, and is much used in graduated instruments, for ast observations. Hunter's screw may be also conveniently used for the same

The most common kind of screws are those used by carpenters a mechanics, for fastening wood, or wood and metal together, and are

ually termed in this country *wood-screws*, though the Scotch name of *screw-nails* is somewhat more appropriate, as distinguishing them from other kinds of screws.

The blanks for wood-screws are forged by the same class of workmen as make nails; they in fact closely resemble the counter-sunk clout nails, with the exception of their ends not being pointed. An improvement upon this method has been adopted by some screw manufacturers, which consists in making the blanks out of round rolled iron, cut into the requisite lengths, and then pinching these pieces, when red hot, between a pair of clams or dies, in the chaps of a vice, and forming the heads by a hammer, or the stamp of a fly-press. To form the threads, files were used in the infancy of screw-making, but this process has been long superseded by the modern practice of cutting and tapping. The forged blanks being well annealed, their small ends are successively placed into a pointed chuck, at the end of a steel mandril, where they are griped fast and made to revolve, while a file is held against them, to brighten their stems and the countersinks of their heads. The blanks are then released, their heads filed flat, and the nick for the screw-driver made by a circular saw. The blanks are now ready for tapping, by a small apparatus similar to the common lathe, as represented in the following cut. At *a* is a steel cylindrical mandril, about



twelve inches long, revolving in collars in the puppets *b b* by the motion of a strap passing round the pulley *c*; *d* is a loose pulley to carry the strap when thrown off *c*. At *e* is an iron box made to open and firmly fix by screws the end of the *regulating-screw f*, of which there are as many provided as there are varieties in the threads of the screws to be cut; they are usually five or six inches long; *g* is the chuck in which the screw is fixed, by means of a kind of hasp or shackle bolt with its end projecting as seen at *h*; whence it is projected by the revolution of the regulating screw, between a pair of cutters or dies at *i*, of the same degree of fineness as the regulator screw used. The shape of the thread or worm itself depends, however, upon the form of the operating edges of the cutters.

The patent screws manufactured by Mr. Nettlefold, of Holborn, are made with great attention to the perfection of the worm; the upper side, as intended to be represented in the following *Fig.* 1, is very flat, or inclined but very little from a plane, passing through its diameter, which causes a great resistance to its being forcibly pulled out of the wood; and the under side of the worm is considerably inclined, which greatly facilitates its entrance into the wood, rendering it unnecessary, in soft elastic woods, to bore any hole for its reception; the form is best seen in the sectional representation of a portion of the screw in *Fig.* 2, the black space being the screw, and the tinted parts on either side, a portion of the wood; also exhibiting the facility of entrance, and the difficulty of drawing out. The greater part of the common wood screws sold in the shops, are, however, very wretchedly constructed, in this as well as other respects. *Fig.* 3 shows a section of their shallow, rough, and imperfect worms, the heads, stems and nicks in which are fit accompaniments to articles so fabricated. The chief defects of common wood screws, besides bad threads, are the having, at the termination of the worm, a projecting burr, which is apt to

tear away the wood before it, and leave little or no solid matter for the screws to hold by; the nicks in the heads being too shallow, or highest in the middle, preventing the screw-driver from taking an efficient hold to turn them in and

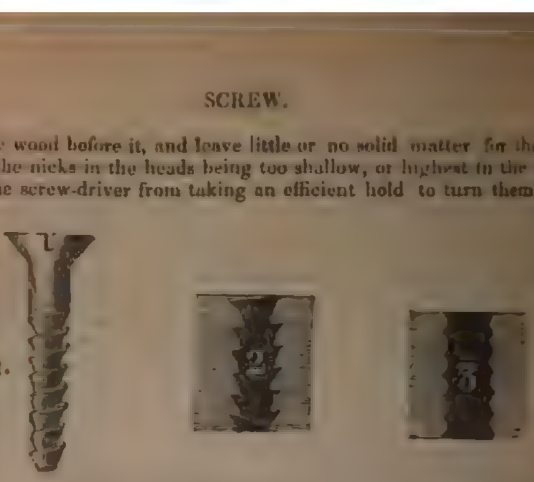


Fig. 1.

out. These defects are carefully obviated in Mr. Nettlefold's screws, and they are made with extraordinary truth and beauty, notwithstanding the very low prices at which they are manufactured.

The machinery by which wood screws are made vary considerably in the different manufactories, and numerous patents have been successively taken out for improved processes; in several of which, attempts have been made, with partial success, to fabricate them without the intervention of human hands farther than furnishing the raw material to the machines. Several persons have succeeded in *casting* screws, —an operation of a very curious, and, apparently, difficult nature. A Staffordshire manufacturer of the name of Maulla, had a patent for an ingenious process of this kind, which is described in the 13th volume of the *Repertory of Arts.*

Immense quantities of screws, of the smaller kind, are made from wire, in the neighbourhood of Birmingham and Wolverhampton. They are chiefly made in the houses or cottages of the workpeople, wherein the children materially assist; the screwing being effected by turning a winch handle fixed to the end of a cylindrical mandril, the other end of which is furnished with a chuck to contain the screw blank, which is thrust forward and turned round between steel dies fixed in a puppet head, the action being regulated by a screw thread on the mandril, taking into a hollow screw fixed in an intermediate puppet head.

In the 41st volume of the *Transactions of the Society of Arts*, is described a very convenient and simple tap (invented by Mr. Siebe, of the Strand) for cutting hollow screws in wood, by which workmen are enabled with the same tool to form either right or left, single, double, or treble hollow screws of the same diameter. The screws capable of being made by this implement, are, however, far from being mathematically accurate, but will be found to be quite as good as the hollow screws made in the usual way, and adapted to the use of various wooden articles of domestic furniture, and to some common kinds of machinery.

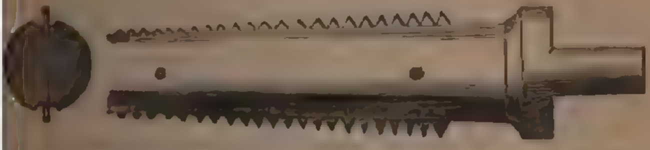
The tap is a thin quadrilateral piece of steel, of the length and breadth of the required screw, having its longitudinal edges cut into saw teeth; the teeth in one row being opposite to the intervals in the other, and therefore representing a section of a screw, the teeth being sections of the threads. A cylinder of hard wood is turned, so as to correspond with the dimensions of the intended screw, and a longitudinal piece being sawn out from the middle, representing a section through the axis, the serrated plate is to be inserted and firmly riveted in its place. The cylinder terminates in a flat head, for the purpose of receiving a key or lever, which enables the workman to overcome the friction experienced in cutting the screw.

In order to use this tool, a cylindrical hole, equal in diameter to the cylindrical stem, is to be bored in a piece of wood, and the serrated cylinder being

introduced, giving it a circular or spiral motion, will form a right or left-handed screw, according to the direction in which it is turned; and by entering two or three threads at once with a common V tool, the same tap will give a double or treble-threaded screw.

The hard wood being first made into a screw, the blade is rivetted in, and the teeth are made by a file to fit the wooden threads; the blade is then removed, the threads in the wooden cylinder are turned off, leaving it smooth; the blade is then tapered at the point, so that the first teeth are no bigger than the former; it is then rivetted again in its place, and the instrument is complete, as represented in the subjoined *Fig.* 1. *Fig.* 2 is an end view of the same, which is exhibited to show that the cylinder is cut away a little where the teeth

Fig. 2. *Fig.* 1.



are inserted, to make room for the shavings. As the cylinder fits the hole, and the blade is taper, a gradual and steady cut is secured, which may either be to the right or left hand.

Mr. Siebe also proposes steel taps for metal screws to be made in the same manner, by filing away a solid screw of metal, so as to present two cutting edges, similar to those attached to the wooden cylinder.

SEWER. A subterraneous channel or canal, formed in towns and other places, for draining and purifying them. They are made of such materials and forms as suit the circumstances of the locality, and come too often under the observation of the public to need our explanation. But in connexion with this subject we may mention the scheme of *Subways*, proposed by Mr. John Williams, of Cornhill, for which he took out a patent in 1822, and strove vainly to get adopted in the city of London. The title of the patent explains its object, viz., "a method to prevent the frequent removal of the pavement and carriage paths for laying down and taking up pipes, and for other purposes, in streets, roads, and public highways."

The nature of Mr Williams's plan will be fully understood on inspection of the annexed drawing, representing a transverse section of the street.

r r represents the paved road-way; *f*, the foot-pavement; *b*, a section of the front wall of the basement story of a house, with a pipe *p* to supply water from one of the mains *o*, contained in the sub-way. The opposite side of the diagram is incomplete, having been cut off for want of room; the pipe *p* there shown is for the supply of the house on that side, with either gas or water; the upper pipes, which may be supposed to belong to different companies, are suspended to the crown of the arch by iron straps. The lower pipes are supported upon the floor; *m m* shows the outline of the masonry; *s*, the common sewer, which has, at stated distances, openings into the sub-ways, but secured by air-tight doors, to prevent the escape of effluvia; *l*, one of the holes covered with a grating, for the admission of light and the circulation of air. The patentee proposes to build his "sub-ways," (as he terms them) when practicable, over the sewers, with drainage from them into the sewers; the dimensions are stated 7 feet high and 4 feet wide, but these may be varied according to circumstances. Openings are to be made on the tops of the sub-ways, or tunnel, at every hundred feet, for the purpose of admitting air and light; and passages are to be made in the sides, to admit inspectors and workmen. Along each side of these tunnels are to be arranged pipes, to supply the inhabitants of the streets under which they are built with water and gas.

Amongst the advantages enumerated by the patentee to be derived from the introduction of sub-ways, may be noticed the facility with which a line of pipes may be deposited along a street, without breaking up the pavement, and the consequent annoyance to the inhabitants, obstruction to the passengers, and detriment to the stability of the roads; the immediate access at all times to inspect the pipes, effect the requisite repairs, or obtain an additional supply of water in cases of fire, and better opportunities of repairing and cleaning the common sewer, whether it be situated underneath or alongside of the sub-way.

SHEATHING, in *Naval Architecture*, a sort of covering nailed all over the outside of a ship's bottom, to protect the planks from the ravages of worms. Formerly, this sheathing consisted only of boards tarred and payed over, but now copper is resorted to, not merely as a substitute, but as an additional covering, and it has become almost universal, where the expense can be sustained; it is of especial utility in vessels making long voyages and into warm climates. The rapid corrosion of copper, by the action of sea water, renders the frequent renewal of it a very serious item of expense to the ship-owner. In a patent which Mr. Robert Mushet took out a few years ago, "for certain means or processes for improving the quality of copper and alloyed copper, so as to render it more durable when employed as sheathing to ships bottoms," he states, that, owing to some defect in the manufacture of the copper, the sheathing upon a ship is sometimes worn away by oxidation in a much shorter period than usual. The cause of this Mr. Mushet considers to arise not simply from the impurity of the metal, but from the undue proportion of the alloy with which it may be mixed. He also states, that he has found that the purest copper, exposed to the action of sea-water, is not so tenacious as when alloyed in the manner he proposes in his specification, and on which he founds his patent. He directs, that to 100lbs. of copper is to be added 2 oz. of the regulus of zinc, or 4 oz. of the regulus of antimony, or 8 oz. of the regulus of arsenic, or 2 oz. of grain tin. Instead of these alloys separately, they may be employed in conjunction in the following proportions: viz. to 100lbs. of the copper add half an ounce each of the zinc and tin, 1 oz. of the antimony, and 2 oz. of the arsenic.

Mr. Christopher Pope, of Bristol, took out a patent, in 1824, for the manufacture of metallic sheathing in which copper is altogether discarded. These plates are composed of tin and zinc, or of tin, lead, and zinc. Mr. Pope says in his specification,—"To unite tin and zinc, I take a certain quantity of zinc and melt it in an iron pot, and when melted, I add an equal quantity of tin, and having stirred them together in a fluid state, I cast cakes of it in moulds of about 8 inches broad, 10 inches long, and ¾ of an inch thick, which cakes are afterwards hammered or rolled out into sheathing. . . . . . To unite tin, lead, and zinc, I melt a certain quantity of lead, and add to it twice the quantity of

composition I cast into small lumps, and having melted three times as I had previously melted of lead, I then add the small lumps of ..., and melt the whole together; which method I find to be the best." ...s he casts into cakes of the size before mentioned, and then rolls ...heets; and he particularly enjoins, that no more heat be used than ...ient to compound the alloy, as the metal becomes hardened by an ...eat; and that it is advisable, in rolling out the cakes, to heat them ...erature of boiling water, by which he says that "they will roll ...er than when cold." This metallic sheathing has, we are informed, ...xtensively employed for covering of the tops of houses, than the ...hips.

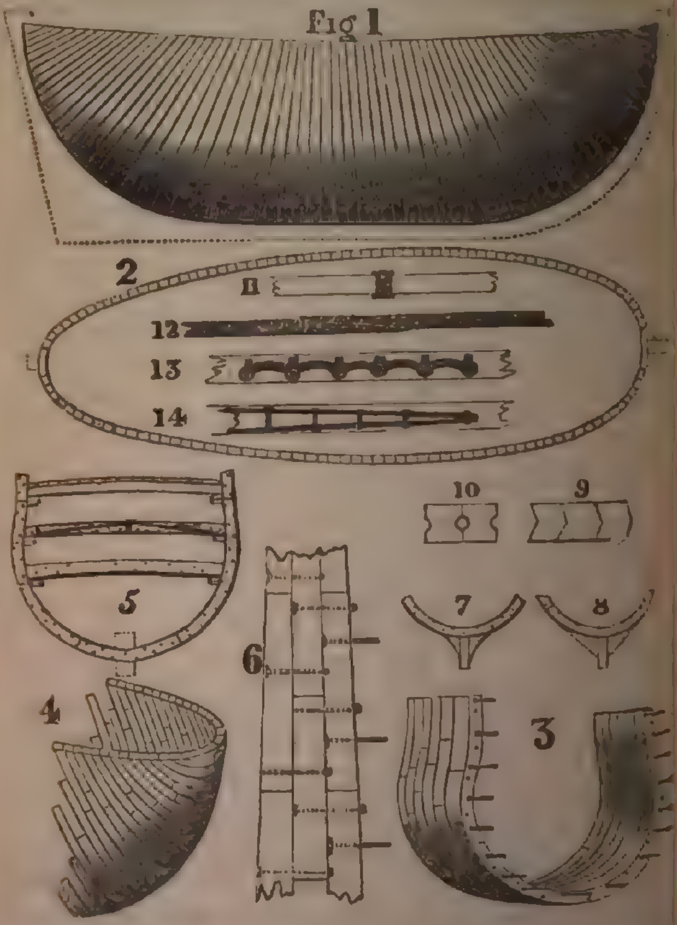
...rs ago, some very favourable accounts were published of the patent ...er sheathing, consisting of a coarse fabric of fibrous material, ...ith a solution of the elastic resin, together with pitch and tar. The ...sheathing was ten pence per sheet, of the size of 34 inches by 20. ...d to be a complete protection against the worm, and must, at the ...ok, form an improved substitute for the felt in general use.

...e some time supposed that Sir H. Davy had discovered a remedy ...rapid oxidation of the copper. Regarding the action of the sea-...copper as of a galvanic nature, that great chemist considered that, ...ion of small pieces of tin and zinc, the copper would be rendered ...lectrical, and oxidation prevented. Ships were sheathed on this ...d sent to sea; but they proved such bad sailers, from the foulness ...ms, that a negative was soon put upon the scheme. It is true that ...was thus protected by the zinc and tin, but the barnacles (shell fish) ...mselves so much to the protectors, as to introduce a greater evil ...ere calculated to remedy. Sanguine hopes were entertained of the ...his plan, and the disappointment consequent upon failure was, of ...sively felt. Founded upon the same theory of the galvanic influ-...nt was, a few years ago, obtained by Professor Pattison, for making ...plates, protected by zinc, which, it was asserted, entirely prevented ...n of the iron: and that a ship sheathed with iron and little bits of ...n two years at sea, and returned home with a clean and bright sur-...specification of the patent states that the iron plates may be of the ...sions of the copper plates, and for each area of 100 inches in the ...of zinc of from one eighth to one fourth of an inch thick, equal to ...in area, is attached to the lower extremity of the sheet, so that in ...the vessel from the upper part downwards, each succeeding sheet of ...be in contact, by lapping over, with the zinc plate of the sheet ...above it. Plates of zinc must also be attached to the inside of the ..., bearing a proportion in area to those on the outside, of 3 to 5. ...and bolts by which the sheathing is fastened to the vessel are each ...ed with a disc, or washer, of zinc, fitting closely to the head; and ...ended that they be driven well home, to insure perfect contact. ...ployed are to be made concave under the head, and the cavity is ...ith melted zinc. The proportion of five square inches of zinc to ...of the iron, is not insisted on; any greater proportion will be ...tual, and the zinc may be alloyed with copper, tin, or lead, in the ...of from 3 to 10 per cent. By this mode of sheathing vessels, it is ...the specification, that the corrosion or oxidation of the metal will ...not entirely, prevented.

The general name for any large vessel fitted with one or more ...ls, for the purpose of navigating on the sea. The name ship is, ...re strictly and properly applied to a vessel with three masts and a ...ch mast consisting at least of two, and most frequently of three ...parts; namely, lower-mast, top-mast, and top-gallant-mast, each ...ing its corresponding yard carrying a square-sail rigged aloft, ...t also being fixed, and furnished with sprit-sail-yard, jib-boom, ...distinguishing features of sea-going vessels of other descriptions ...under their respective heads; and as it will not accord with the

prescribed limits of this work to enter at large into the subject of nav architecture, we shall in this place introduce to the attention of the rea some interesting improvements and suggestions, which have recently be made by ingenious and scientific men.

A few years since, Mr. David Redmund, an engineer of the City-ro London, (who was originally a shipwright,) took out a patent for impro ments in the mode of constructing the hulls of ships and other vessels, t main objects of which were the obtaining of a more effectual security agai shipwreck, and facilitating the general adoption of steam navigation. Th



annexed description, together with the observations upon it, we extract f the specification of the ingenious patentee.

"The present mode of framing the hulls of vessels leaves a vac between the ribs and frames, which said ribs or frames are not fir connected together, so as to unite their strength, until the planking is al to them; so that, previous to planking, the hull has no strength whate Now as this is, I conceive, the foundation of the structure, I respectfully sub that, when in that state ready for planking, the vessel should be, if possibl

a strength to resist all such shocks or concussions as vessels are liable to th; so that when planked, she should acquire the full portion of al strength which can be imparted to her construction by that process, the shocks or concussions to which all vessels are liable, should not ved on, or affect, the tree-nails, or bolts, which secure the planking to ne of the vessel. Now, as the present vessels, previous to planking by their constructions, capable of supporting themselves, and only strength by their planking being secured to the frame or timbers, by tree-nails or bolts, I presume it is evident that the greatest portion of olent strain, shock, or concussion that the vessel is subject to, must, in measure, be received and sustained, in some direction or other, by the d wooden tree-nails or bolts, which have first given strength to the fabric ing the frames and planking together. The ribs or timbers not nuted close together, there seems to be nothing to prevent the portion of the shocks being received by the tree-nails or bolts; the n of the shocks soon works the tree-nails loose in their holes, and els then become crazy and leaky; which shows clearly how very ate they must be for the purpose of sustaining any lengthened ation of such strains and concussions as all vessels are liable to. In struction of vessels I have no vacancy between my ribs or timbers; but at the middle of the ship, and bolt each rib or frame firmly to its inserting the bolts in each that are to receive the next, as shown in *Fig.* 3, hows six of the first ribs connected together, with the heading joints crossed, and the bolts standing out to receive the next rib; so I work d left to the head and stern, as shown in *Fig.* 1, which is a longitudinal of all the ribs or timbers, showing the bolts let in at the heads to admit rib being bolted close to its fellow, each requiring to have holes made in o receive the nut of the bolts of the previous one, as is seen in *Fig.* 1. ding joints are each grooved a little way in, and a tongue or tenon of riven in after it is in its place, which will serve as a stop to the caulking, e steadiness to the ends; and the tongue or tenon should enter about an more into the ribs on each side. It will be requisite to have as large or plates under the heads of the bolts, and also under the nuts, as the the timbers will admit of, only the edge of the plates should not come three quarters or half an inch of the face of the timbers; so that, ulked inside and out, both bolts and plates are secured from air and The holes for the bolts should be about one-fourth of the thickness, or more, from each edge; so that, if the timber were eight inches, the f the hole should be about two inches and a quarter, or two inches and rom each edge. It may be found proper in some light constructed to have the bolts in the centre of the timbers; in such cases the vessels exceedingly strong, but will not be so stiff as the other way. It will be *Fig.* 1, that all my timbers are made smaller at the upper end, and the lower part next the keel; and, as every good practical ship-builder inted with the prevailing methods of striking out the timbers to stand ngle or inclination, I need only remark, that the angle of inclination I have shown the timbers, appears to me to be the best. But if the xperience should suggest any alteration, it is easily done by making the more or less of the wedge form, as may be found best.

section No. 1 also shows the timbers are of various dimensions, as it is olutely necessary they should be all of one size, only they should be in proportion, so as to keep the proper angle; but they should of the same dimensions the other way, so as to produce an even for the planking, as at present; and I should always keep my timbers fullest dimensions from outside to inside, as the more I increase the of my abutments, the greater the stability of the vessel,—always bearing that I am constructing an arch, to be self-abutted in every direction. I ucr the thickness of the planking, and increase the thickness of the and, by so doing, greatly increase the strength of the vessel; and as and stability are the principal objects I propose to obtain by my im-

provements, in those parts of the vessel at or near the head or stern, where the ribs form a sharper or more acute angle at the keel, as shown by *Figs.* 7 and 8, I would keep the line of the timbers more to the circle, to admit of the timbers which cross the keel being cut out of trees of moderate dimensions, without the grain running too much across, and to fill out the shape with what is technically termed dead wood or chocks, as shown by *Figs.* 7 and 8, which should be secured to the rib, and bolted to its fellow piece; which, by increasing the surface of the abutments, adds stability to the arch, and proportionate strength to the vessel.

"If any objection should be made about the quantity of dead wood or chocks accumulating, by adhering strictly to the rule laid down as relative to *Figs.* 7 and 8, I would wish it to be understood, that if the ribs were prepared for those parts as they are at present, only to diminish them from the top to the bottom, as before stated, and bolt them firmly together, and to the keel, as at present, the vessel would be infinitely stronger than by the ordinary mode, but would not, in my opinion, be of equal strength and durability as if executed agreeably to the rule laid down in *Figs.* 7 and 8; as, on my plan, if the whole of the keel, stern-post, and the dead wood, were all carried away, the frame of the vessel would remain firm and secure, and would only have lost the trifling portion of strength she had acquired from her keel and dead wood being affixed to her frame. It may be proper here to remark, that on my improved mode of ship-building, every additional piece of timber affixed to it from the first rib or frame to the last plank, all and every additional piece so affixed brings with it its proportionate addition of strength and stability to the vessel, beyond its own weight. Even what is technically termed dead wood, on my principle, brings its proportionate addition of strength and stability to the vessel, if it is put on, and secured to each rib, and bolted to its fellow as directed.

"The beams on which the decks lay should be secured to the sides of the vessel in the usual manner; but as room is considered a great object between decks, and the present decks, beams, and planking take up from 10 and 11 to 14, 16, and 18 inches, according to the size of the vessel, and the number of decks, &c., I propose cutting oak scantling to the size or thickness of the decks,—say about 6 or 8 inches square, according to the width of the vessel,—keeping the curve of the deck as much as possible,—say about 7 or 8 inches in the width of about 28 or 30 feet, and the scantling about 6 or 8 inches, taking about the same quantity of timber as at present used in beams and planking. These I bolt firmly together (see *Fig.* 5,) after the same manner as the ribs of the hulls, with about three-quarter or seven-eight bolts, according to the rate or tonnage of the vessel. The scantling should be all the length across the vessel, and being bolted together as above, would be found of great strength; but to increase the strength as might be required, I would truss two together at about 6 or 8 feet apart, as in middle-deck *Fig.* 5; or a truss, constructed as *Fig.* 14, might be inserted into each scantling; or a rule joint self-abutted chain, as *Fig.* 13, might be let into the edge of the scantling, for the same purpose: and they should continue through the sides of the vessel, having a stout nut-screw and plate, to enable them to secure the sides firmly to the deck,—thus answering a double purpose; and by having fewer or more of them, the decks may be made of any additional strength required, with an even surface underneath, yet will not take up half the space occupied by the present decks. I merely name these methods, if additional strength should be required; but it is my opinion there will be sufficient strength without them. In vessels where expenses or first cost were not an object, the timbers might be prepared with a circular groove in the centre, (see *Fig.* 10,) in which groove a strongly twisted rope of oakum might be put, which, being left rather large, would, when screwed up tight, form a strong and tough tongue or key, and also a stop for the caulking. The decks, if required, could be done in the same way, and they might be caulked on both sides, if requisite, and if any objection should arise about the joints of the decks running across the ship, they might board it the other way with thin boards (as see *Fig.* 5), or the scantlings might run from head to stern, kept to the curve, and bolted together the same as the others; in which case it would

[illegible] an arch, the abutments of which were secured, but would not be so strong [illegible] the other way. *Fig.* 4 shows how the timbers come to a finish at the head [illegible] circular stern of the vessel. The keel or stern-post is not shown, as it is [illegible] to show how the timbers finish, and also what very short pieces may be [illegible]asionally used; as the strength of the arch does not so much depend on the [illegible]gth of the pieces, as on the increased surface and effectual security of the [illegible]ments. It will be understood that spaces for port holes in ships of war [illegible] be left without materially diminishing the strength of the vessel.

"It is supposed in this description, that the keel is first laid down, as usually [illegible]ne, only its internal edge will be formed to the curve of the under part of the [illegible]ll, exclusive of the filling out pieces or chocks alluded to in *Figs.* 7 and 8. [illegible] improved ship now having her decks in and firmly secured to the beams [illegible] which they rest, and also to the sides, head, and stern of the vessel, after the [illegible]thods before described, I now proceed to caulk all her joints, inside and out, [illegible] her decks also, which being done, she then presents the novel sight of a [illegible]p of great strength, previous to planking; presenting, in every assailable [illegible]ection, the strength and resistance of an arch, self-supported and self-abutted [illegible] every direction,—no bolt or pin, but those which secure the decks to the [illegible]ams, being visible throughout her whole frame, to convey to the beholder the [illegible]ghtest idea of the mode by which her abutments are secured; and her frame [illegible] firmly united together, her invisible endless chains of bolts being perfectly [illegible]cured from air and water by the caulking inside and out, the vessel itself [illegible]ing, of course, water-tight every where, and of incredible strength, as the [illegible]ce of every shock is received on and divided amongst her numerous abut[illegible]ents. In this state, previous to planking, let the comparison be drawn between [illegible] improved ship, and one of the present day, previous to their being planked—[illegible]e of great strength, the other of no strength at all—not being capable of sup[illegible]orting itself until planked. I would now remark, that as the process of [illegible]anking imparts such a great degree of strength to all modern-built vessels, it [illegible]ill, of course, appear to any person, that my vessel must derive a considerable [illegible]ditional increase of strength and stability by that process, as the tree-nails [illegible]hich secure the planks to the frame cannot be disturbed by any shocks or [illegible]rains the vessel may receive, the force of all outward shocks being received [illegible]n and divided among her numerous abutments—and of all strains from weight [illegible]r cargo, on her abutments and bolts, which must be drawn apart before the [illegible]ree-nails can be affected, which cannot occur if they are in proportion to the [illegible]onnage of the vessel. I now plank her; and of course my vessel would admit [illegible]of a considerable reduction in the thickness of the planks of ships of war, which [illegible]may be added to the timbers, how much, I must leave to the discretion of the [illegible]builders, who will act according to circumstances.

"The planking would be fastened, as usual, with tree-nails, as I know nothing better; and as the force of any shock will not now be felt by them, but received on the abutments, they, of course, will now be fully effective. Each alternate rib should be bolted to the keel, and the keelson bolted through each of the others, and through the keel also. The thickness of the bolts will be regu[illegible]ted by the weight and tonnage of the vessel. A vessel of 500 tons should have the six upper bolts within six or eight feet of the top, in the first sixteen [illegible] seventeen central ribs, that is, six on each side of the vessel to each rib; and [illegible]ch bolt should require a force at least equal to 18 or 20 tons to draw it apart. The decks should not have less than three-quarter bolts. The whole of the bolts would be best to have strong-threaded screws, with adequate thick nuts and [illegible] as large as the timber will admit of, and in those of the decks also; should the iron be thought to affect the compass, a great number of these might be copper bolts, of equal or of adequate strength. It must be understood, I [illegible] mention about the number and strength of bolts that should be put in to [illegible] a firm and substantial vessel, with timbers the same size as at present, [illegible] before it is planked; but it is obvious that ship-builders will exercise their own discretion on that head, more or less, according to circumstances; so that some vessels will be so incredibly strong, that a storm, or being driven on shore, would have no effect on them, being equally secure and safe on land and water;

others would not, perhaps, build them so strong; but it is certain, that with the same quantity of timber, and a sufficiency of bolts, agreeably to the scale aforesaid, vessels may be constructed on this principle, of such strength and stability, that to hear of the wreck of one of them would be quite a novelty. With timber and bolts proportionate, there need be no limits to the dimensions or strength of vessels constructed on this plan,—which is what is most wanting in steam navigation, the desideratum being larger and much stronger vessels.

"It will be seen that very strong vessels may be constructed on my principles, with the timbers running horizontally or longitudinally from head to stern, and connected together as before described. But I have described them vertically, as used at present, which I think to be the best, strongest, and simplest method of carrying my improvements into effect; as it is so trifling a variation from the present mode, being simply improvements on the present methods of arranging and connecting their timbers, which, if strictly adhered to, and generally adopted, will put an effectual stop to the appalling annual loss of lives, treasure, and time, to which we have been so long subjected; substituting safety, certainty, and punctuality, in all the future naval and mercantile affairs of this wonderful and enterprising nation,—thus keeping our own proper position in the new era of enterprise opening to our view, in the general adoption of steam navigation for all naval and commercial purposes."

The quantity of timber consumed in the construction of a hull of this kind, is much the same as in one of the ordinary kind—the quantity of bolts about double; but as a great quantity of iron and other work is superseded by Mr. Redmund's plan, the total cost would not be more.

Mr. Annersley's patent plan of building ships and boats is exactly the opposite of Mr. Redmund's, just described; instead of depending upon the rib timbers for the main support of the hull of a vessel, he dispenses with them entirely, and derives the requisite strength from successive courses of planks crossing each other. The following account of the invention, derived from a periodical journal, will be found sufficiently explanatory.

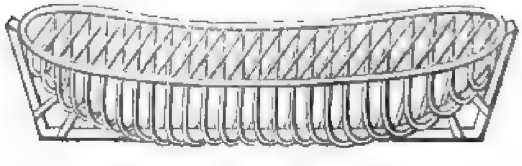
The mode of proceeding is first to form a model of the required dimensions, and regulate the symmetry of the subordinate arrangements accordingly; this done, the model is cut across, by which the form and proportions for the mould are exactly obtained, as shown in the annexed *Fig.* 1. The moulds are

Fig. 1.

(Centre Mould.) *(Section of Model.)*

then set up on the building blocks, in much the same manner as in other vessels; the moulds are of slender materials, merely strong enough to retain

Fig. 2.

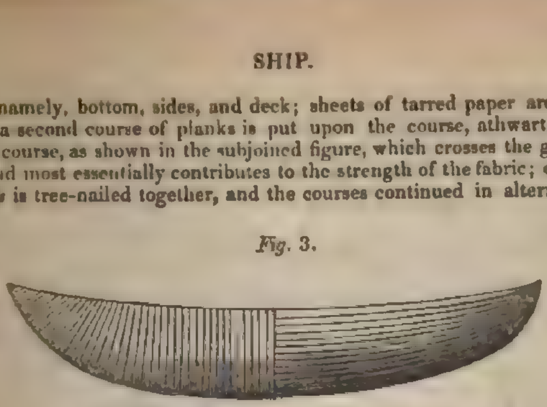


(Perspective View of Moulds set up.)

together the perfect shape of the intended vessel: they are shown in *Fig.* 2. A longitudinal layer or course of planks is then fastened to the moulds all

round; namely, bottom, sides, and deck; sheets of tarred paper are then laid on, and a second course of planks is put upon the course, athwart, all round the first course, as shown in the subjoined figure, which crosses the grain of the wood, and most essentially contributes to the strength of the fabric; each course of *planks* is tree-nailed together, and the courses continued in alternate direc-

Fig. 3.



(The alternate fore and aft and cross planking.)

tions till a sufficient substance is acquired for the strength of the vessel. The keel, stem, and stern-posts, are put on with the last course, as shown in *Fig.* 4, and then the whole are tree-nailed through and through, each tree-nail being driven hard in, then split at the end and wedged. The dead wood fore and aft

Fig. 4.

(Profile of the Vessel complete.)

is formed by cross planking, to fill up the space between the body of the vessel and the stern and stern-posts. To save the bottom, strengthen it, and keep the vessel upright when aground, two bilge keels are tree-nailed or bolted through into bilge planks in the inside of the vessel; stanchions, with brackets, are fixed to the sides and deck, and the bulwarks are formed prior to the last course of planking; the last course is then laid to finish the deck: the hatchway and companions are then cut out of the solid deck, and the comyns introduced. This system of building is said to require much less timber, being without knees, beams, and ribs, and is, therefore, more buoyant—causes no loss of time in building, for seasoning the timber—avoids the dry rot, from air and moisture being excluded from the inner courses—the resistance more elastic, and presenting, in every direction, an arch to sustain external shocks; and, it is added, that in case of warfare, the destructive effects arising from splinters will be entirely avoided.

Mr. E. Carey, of Bristol, who has had much experience in ship-building, and has suggested a variety of improvements, recommends the following method of fastening a ship's side, with his newly-invented iron knees, as explained by the subjoined figures. *Fig.* 1. is a horizontal section of a portion of a ship's side and beams; A A shows the ship's side; B B the timbers; C C the thickness of the outside planking. D D a plank, $3\frac{1}{2}$ inches thick, which goes all round the ship, inside the timbers, against which the iron knees are fixed, and bolted through the side; *e e* an horizontal clamp, 10 inches wide and 6 inches thick, *F F* the iron knees, 4 inches wide and 2 inches thick, which are bolted through

the beams and ship's side, as at G G. *Fig.* 2 is a section of the same parts as *Fig.* 1. H is the plank sheer; I the water way; J J the ends of the planks; K a bolt that goes through the ship's side, through the edge of the water way, and six streaks of the deck below the beam, and is clenched on an iron plate

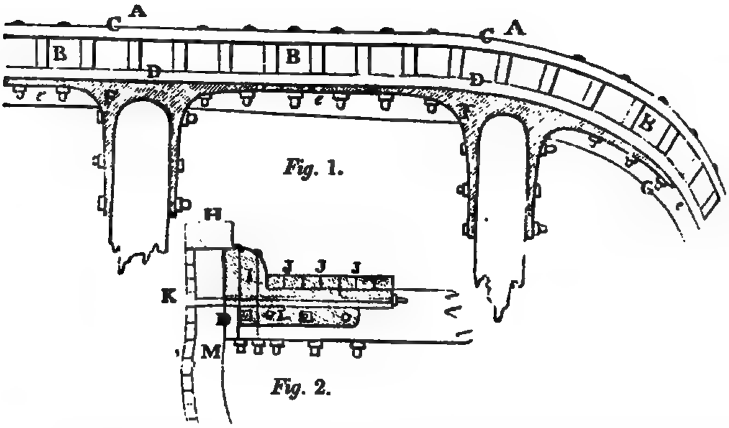


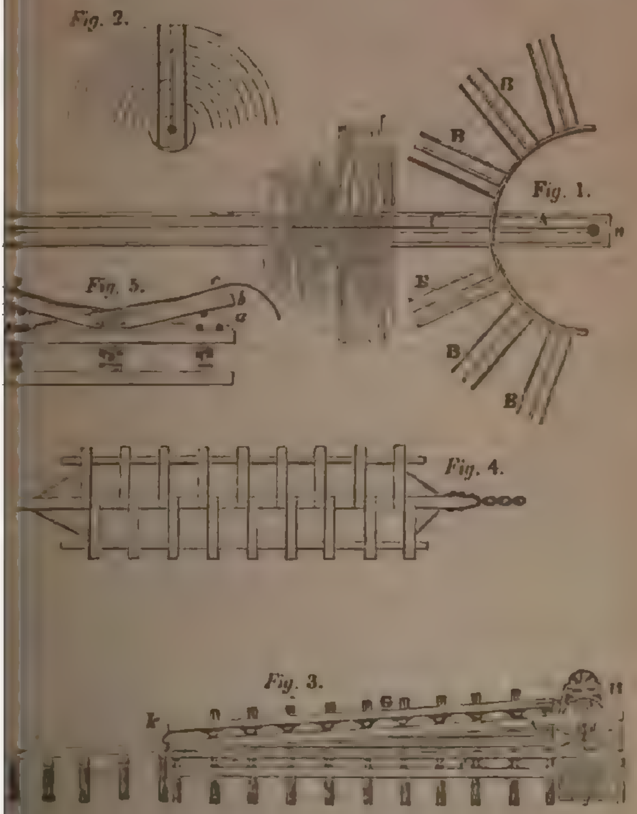
Fig. 1.

Fig. 2.

on the inner plank; L the arm of the knee; M the ship's timber and side; D is an edge-view of the inner plank, as shown at D, *Fig.* 1. These iron knees and water ways are let down upon the beam 3 inches, and also six of the deck planks, and bolted through also; under the beam a plank, 3½ inches thick, is first brought on, inside the ship, against which the ends of the beam are fixed. The horizontal clamp, 10 inches wide and 6 inches thick, is then brought on under the edge of the plank, and bolted through the side. On this clamp the beam is dovetailed in, one inch down, and bolted through the end of the beam. A ship fastened in this way, Mr. Carey says, will render it impossible for the side to move; that no wet can possibly get down, and that the ship will thus be kept perfectly dry and sound.

Under the head Dock have been described the usual mechanical arrangements and process for building and repairing ships. In this place we shall add a very ingenious and improved method of bringing up ships upon the ways for the operations of the ship builder. A Committee of Inventions appointed in the year 1827, by the Franklin Institute of Philadelphia, to whom the subject was referred, drew up the following report thereon, which seems to have been dictated by sound judgment and impartiality. "The Committee of Inventions, to whom have been submitted a model, drawings, and descriptions of the 'Radiating Railways for the repairing of Vessels,' invented by Edward Clark, of New York, civil engineer, report, that they have carefully examined the proposed improvement, and consider the plan as offering great facilities, when it is desirable to have several vessels under repair upon the ways at the same time. Morton's patent slip, which is in use in Scotland, is of sufficient length to contain two or three vessels; but it is evident that whichever was the last hauled up, must be the first launched; and they must, therefore, be frequently repaired in haste, without being allowed that time to dry, which is, in many cases, a point of great importance. To obviate this difficulty is the end proposed in the plan under consideration. It does not appear, from any thing which has been presented to the Committee, that Mr. Clark proposes anything novel in the construction of the lower part of the railway, or of the carriage upon which the vessel is to be drawn up; its distinguishing feature being the means provided for removing vessels out of the direct line of the main railway, and of depositing them upon sub-ways, for the purpose of being repaired. To

…h this purpose the upper part of the railway, for a length sufficient …a vessel, is detached from the lower part, and is made capable of … upon a firm horizontal platform, a perpendicular shaft from which …rough the upper end of the detached part of the railway. This plat…the segment of a circle, but it may, if necessary, present a complete …t the periphery of this segment, the fixed part of the railway terminates, …detached revolving commences; this is supported upon the platform by …nt number of strong iron rollers, placed transversely on the lower part …amework of which it is formed. The upright shaft, around which the



…railway is capable of revolving, is also the shaft of the windlass, by …e vessels are to be drawn up; this detached way may therefore be con… a radius to the circle, of which the platform is a segment. When a …awn up and has arrived upon the movable part of the railway, a power …pplied to carry this with its load to the requisite distance round the …platform, until it arrives at a sub-way, several of which are erected …e platform, forming produced radii to the circle. These are precisely …the main railway, with the exception of their not being continued to …, but only of such a length as to admit of the carriage with its load …ored, and deposited upon them until the intended repairs are made.

In the drawing which accompanies this report there are represented six sub-ways, and of course upon such a structure seven vessels might be placed at a time. The main expense attending the erection of marine railways, is in constructin that part which is under water, where nearly the whole of the labour must b performed in the diving-bell. In the mode proposed by Mr. Clark, one marin railway would be sufficient in those parts where many vessels may be require to be hauled up; a considerable number of sub-ways, with their appurtenance might undoubtedly be provided at an expense far below that which would atte the original structure. After maturely considering the subject, the Committe are fully convinced of the practicability of the plan, and also of its economy, i those situations where more than a single railway would be desirable. Whe once constructed, it possesses the advantage of being capable of extension i the number of its sub-ways, whenever it may be required." Annexed a engravings from the drawings referred to. *Fig.* 1 is a bird's eye view of t platform and railways. A, revolving section of the railway, which may pleasure be made to coincide and connect with the radiating or sub-ways BB or with the main railway C, extending into the water. D is the shaft or piv upon which the section A revolves. *Fig.* 2 represents the revolving sectio with its centre, as in *Fig.* 1, together with the circular iron railways, up which the cast-iron rollers are to run. *Fig.* 3 is an elevation or side view of t revolving and permanent railways, supporting a ship's carriage; A being t revolving section; B or C, section of the main, or the sub-railway; D shaft f communicating to the windlass the power which is generated at the levers; this shaft is also the pivot around which the section A is made to revolv *e e e e*, &c., are iron rollers connected to and supporting the revolving sectio in the circular railways; G, ship's carriage resting on the inclined railways; I windlass or other machinery for elevating vessels; *i*, chain by which the carriag is drawn up; *k*, palls to prevent the carriage from running back; *l*, frictio rollers, lying between the movable and fixed ways. *Fig.* 4, ground view of ship's carriage. *Fig.* 5, transverse view on a larger scale of a ship's carriage the railways; *a a* cuneiform blocks, movable on rollers, in appropriate groove to prevent lateral motion; *b b*, bilge blocks moving on pivots, and resting o rollers adapted to *a a*; *c c*, ropes by which the cuneiform or wedge blocks ar drawn up, and the bilge blocks forced against, and adapted to, the bottoms o vessels.—*Franklin Journal.* For a variety of information of the constituen parts of ships, with their recent ameliorations, see the separate heads, as Mast Rudders, Capstan, Windlass, Blocks, Anchors, Fids, Boats, &c. &c.

SHINGLES, in *Building*, small boards, nearly resembling, in shape an size, the staves of a common pail, but tapering regularly thinner and thinne from the broad to the narrow end. They were formerly used instead of tile for the covering of roofs, and are well adapted to those that are of a hig pitch, but not so well for the modern low roofs. The steeples of many of ou country churches are covered with shingles. The method of covering a buildin with shingles is extremely simple; at equal distances from the thin end the are inserted two stout wooden pegs, projecting on the inner side about tw inches: by these pegs the shingles hang on pantile laths, nailed horizontall across the rafters, and at such distances, as to allow each row of shingles to la over the next lower row by about half the length of a shingle. Sometime however, the roof is previously covered with boards, on which the shingles a nailed; but this method has the disadvantage of being far too expensi for common practice, especially in a country like ours, where oak is by means plentiful, and what we have is wanted for purposes of greater nation importance.

SHOT. A missive weapon discharged by the force of ignited powder fro a fire-arm in warfare: of these there are various kinds, as round shot, or bu lets, a ball or sphere of iron whose weight is in proportion to the bore of t cannon. Double-headed, or bar-shot, are formed of a bar of iron with a b at each end, which fits the muzzle of the cannon. The middle is sometim filled with composition, and the whole covered with linen dipped in brimston so that the cannon, in firing, it is said, thus inflames the combustibles or co

..., which sets fire to the sails of the enemy. One of the heads of this ball ... hole to receive a fusee, which, communicating with the charge of the ..., sets fire to the bullet.

...in shot consist of two balls chained together, being principally designed ... oy the enemy by cutting her sails, rigging, &c. Grape shot is a combi... ... of balls strongly corded in canvass upon an iron bottom, so as to form a ...rical figure, whose diameter is equal to that of a ball which is adapted ... cannon. Case shot, or cannister shot, are composed of a great number ...ll bullets, put into a cylindrical tin box. They are principally used when ...ear, to clear the decks of the enemy. Besides these, there are others of ... pernicious kind, such as langrage shot, star shot, fire arrows, &c., ...yed also when not at a great distance from the enemy.

...non shot that are cast in moulds, usually possess, in a greater or less ..., the three following defects:—first, being imperfect in their spherical ..., which is owing to the expansion and alteration of form made in the ..., from frequently heating them; second, containing air cavities, owing ... air being caught in the moulds when the fluid metal runs in too quickly ... to escape; third, their having usually an indentation where the metal is ... in. To obviate these defects, Mr. Boothby, of Chesterfield Iron Works, ...actures his cannon balls in the following manner, for which he has taken ... patent. A solid ball of hard wood or metal is turned to a true sphere ...ding to the size or weight of shot required), and then cut in halves. ... halves are moulded in sand boxes, in the usual manner of other castings, ... care that the sand be well rammed; then taken out, and the hollow ... thinly coated with powdered charcoal mixed with water. The boxes ...ing the moulds are next dried in the stove, preparatory to receiving the ...etal. The shot thus cast are said to be perfectly sound and spherical, ... to the air escaping through the sand, and the mould being unaltered in ...e by heating.

...ROUDS. A range of large ropes, extended from the mast heads to the ... and left sides of a ship, to support the masts, and enable them to carry ... The shrouds, as well as the sails, &c., are denominated from the masts to ... they belong; thus there are the main, fore, and mizzen shrouds; the ... top-mast, fore top-mast, and mizzen top-mast shrouds; and the main ...llant, fore top-gallant, and mizzen top-gallant shrouds. See SHIP.

...UTTLE. The instrument employed in weaving, by which the crossing ... threads is mainly effected. See WEAVING.

...KLE. An instrument for cutting down corn. It is simply a curved ... or hook of steel, with the edge, in the interior of the curve, serrated, so ... make a cut like a saw. The subjoined engraving, which represents the ... instrument used by the Singalese, shows that the sickles employed by the

...arbarous nations of the East differ in no essential respect from those ... this country.

...VE. An instrument for separating the smaller particles of substances ... grosser; they are made of various forms and sizes, to suit the article ...ifted. In its most usual form it consists of a hoop, from 2 to 6 inches in ... forming a flat cylinder, and having its bottom constituted of coarse or ...air, canvass, muslin, lawn, net-work, or wire, stretched tightly over, ...ing to the use intended.

There is a kind of sieve in extensive use amongst druggists, drysalters, and confectioners, termed a drum-sieve, owing to its form, and is used for sifting very fine powders. It consists of three parts or sections; the top and bottom sections of which are covered with parchment or leather, and fit over and under a sieve of the usual form, which is placed between them. Being thus closed in, the operator is not annoyed by the clouds of powder which would otherwise be produced by the agitation, and the material under operation is thus saved from waste.

SILEX, silica, silicium, or silicious earth, is one of the most abundant substances in nature, constituting the entire mass of many mountains, and probably of a large portion of the globe itself. It is the chief component of sand, sandstone, flint, granite, quartz, porphyry, rock-crystal, agate, and many precious stones; it is the chief substance of which glass is made; also an ingredient, in a pulverised state, in the manufacture of "stoneware," and it is essential in the preparation of tenacious mortar. Silex, when pure, is a fine powder, hard, insipid, and inodorous; rough to the touch, scratches and wears away glass. It does not form an adhesive mass with water, but falls to the bottom, leaving the water clear: however, if the silex be very minutely powdered, a small portion of it will be dissolved by the water. Silex may be obtained in a pure state by igniting powdered quartz with three parts of pure potash in a silver crucible, and adding to the solution a quantity of acid sufficient to saturate the alkali; then by evaporating to dryness, there will remain a gritty powder, which, when washed with water, will be pure silex.

SILK. A very soft, fine, bright thread, the production of different species of caterpillars; but the bombyx mori, or silk-worm, is chiefly cultivated for this purpose; it is a native of China, and the culture of silk in ancient times was entirely confined to that country.

The natural history of the silk-worm forms a subject highly interesting and curious; but the extraordinary changes which the animal undergoes, as well as its manner of spinning its ball or cocoon, having probably fallen under the actual observation of most of our readers, we shall pass over this part of our subject, and proceed to the business of winding, throwing, and weaving.

In those countries where silk forms an important article of commerce, the cultivators, or those who rear the insects, do not wind off the silk themselves, but sell them to others, who make the operation of reeling a distinct business. The single filament, or thread of silk, as produced by the worm, is of such extreme tenuity as to be totally unfit for the purposes of the manufacturer. Therefore, in winding it off, several of the cocoons are immersed in warm water, to soften the gum with which the silk is naturally connected; their several ends are then joined and reeled off together; and, by the adhesiveness of the gum, are thus formed into one smooth even thread. When the thread of any cocoon breaks, or comes to an end, its place is supplied by a new one, which is simply laid on the main thread, to which it adheres by its gum; and, owing to its extreme fineness, it does not occasion the least perceptible unevenness in the place where it is united. In this manner of joining the separate filaments, a thread may be made of any length.

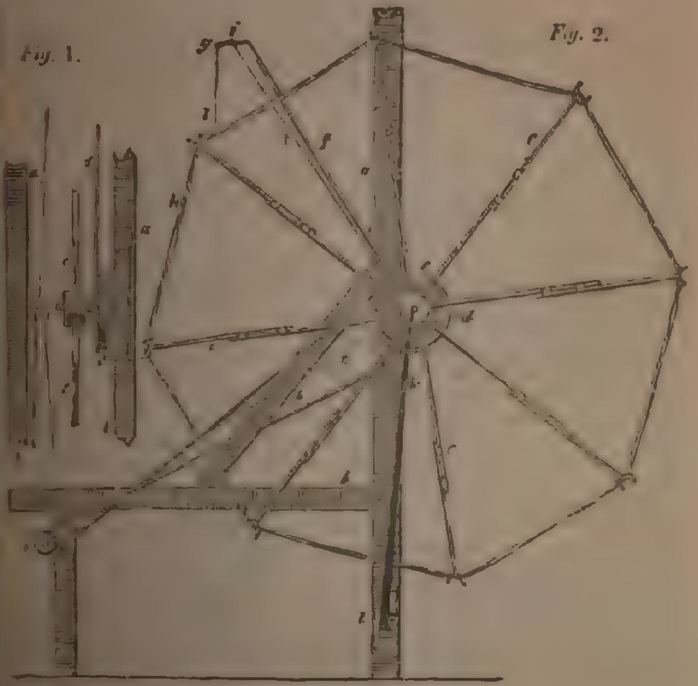
The apparatus for reeling consists merely of an open kettle of water, under which is a fire to keep it warm; and the reel is of the common construction. However simple the operation, great care and attention are necessary in reeling, to preserve the thread of an equal thickness, and of a round form, and that the several rounds upon the reel should not get glued together. When the skein is quite dry, it is taken off the reel, and being made up into hanks, it forms the article called, in commerce, raw silk, of which such vast quantities are annually imported into this country from Bengal, China, Italy, and Turkey.

In preparing raw silk for dyeing, the thread is slightly twisted, in order to enable it to bear the action of the hot liquor without the fibres separating or furring up. The silk yarn employed by the weavers for the woof or weft of the stuffs which they fabricate, is composed of two or more threads of the raw silk slightly twisted by the aid of machinery; and the thread employed by the

stocking weaver is of the same kind, but composed of a number of threads corresponding with the strength or quality of the work he is executing.

The first operation it undergoes is winding; that is, drawing it off from the skeins in which it is imported, and winding it upon wooden bobbins, from whence it is taken off for subsequent operations. In the ordinary method of winding off silk, the reel or swift, upon which the skein is placed, is made to revolve by the pulling of the thread, as it is drawn off and wound upon the bobbin. The great delicacy of the filaments of silk often, however, render this operation difficult, owing to the breaking of the threads; in the winding of Turkish silk, in particular, the process is, from the circumstance just mentioned, extremely tedious, as the thread breaks at almost every turn of the reel, this is owing to the great size of the Turkish skeins, which frequently exceed twenty-four feet in circumference; thus requiring a reel of equal dimensions, that has to be turned round by a single thread; and this thread, being of an uneven thickness, frequently gets entangled in the skein, and unavoidably breaks. To obviate so great an inconvenience and detriment to the material (by an infinity of knots in the thread), the attention of Mr. H. R. Fanshaw was directed, and by means the most simple and ingenious he accomplished his object in the most happy and perfect manner; this invention, for which he took out a patent in 1827, we shall here describe.

Fig. 1. Fig. 2.



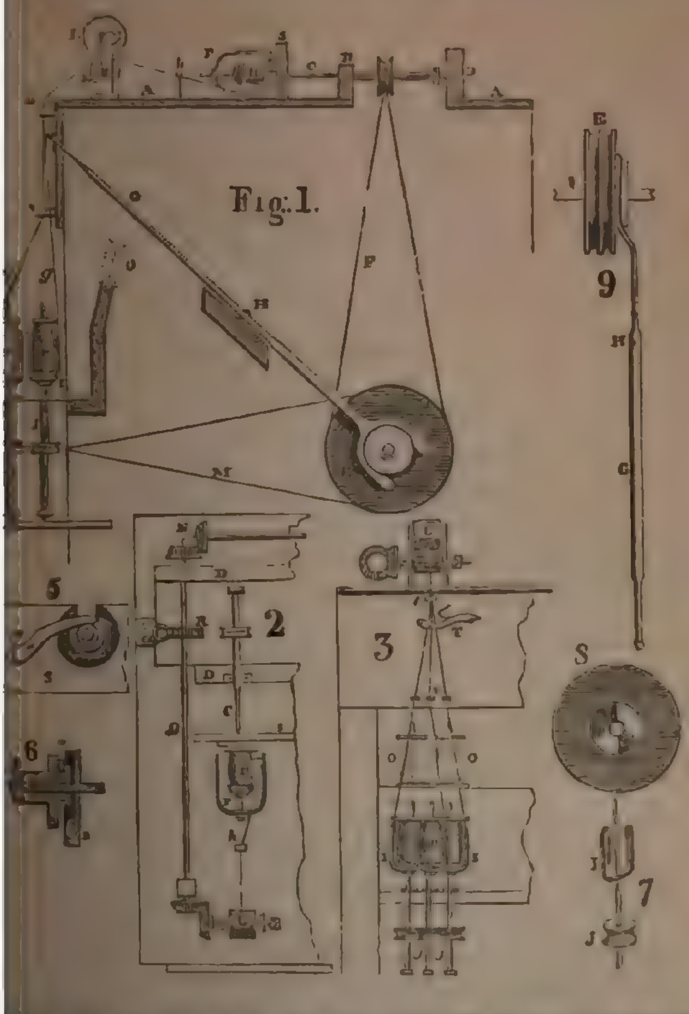
Instead of the reel being turned round by the filament, it remains stationary, but is suspended loosely upon its axis; a light arm or flyer is then made to revolve around the external circumference of the reel, which lifts out the thread from the skein more smoothly and delicately than it could be performed by the finger, conducts it to the centre of motion, and from thence to the bobbin on which it is wound. By this contrivance the thread requires but little more

strength than is sufficient to sustain itself, instead of having to drag round a great machine; and it follows that a much finer thread may be wound off by such apparatus than by those of the common construction. Our limits do not permit us to give all the details of this machinery; we shall therefore confine ourselves chiefly to explaining the principal or most important parts, as represented by the annexed diagram. *Fig.* 1 gives a side elevation, and *Fig.* 2 a front elevation of a portion of *Fig.* 1; the same letters in each referring to similar parts. *a b* is a frame, containing a swift, &c., of which there may be conceived to be a hundred or more in a row, one behind the other, as viewed in *Fig.* 1, all turned by the same shaft; the diameter of the swift may be considered as eight feet for Turkey silk, but the arms *c c* are made to elongate or shorten by the slides shown in the middle, so that the swift may be expanded or contracted at pleasure to suit the size of the skein; each of these radiating arms is fixed into a central block or nave *d;* through this nave a spindle passes, on which the swift loosely rests, as best seen in *Fig.* 2; *e* is a pulley, which revolves on the same spindle, and receives its motion by an endless band from another pulley at *o*. To the pulley *e* is affixed the revolving arm *f*, which is furnished at its extremity with a bent wire, coiled up into two spiral eyes; through that at *g* the filament of silk *t t* passes as it is lifted by it out of the skein *h;* from *g* it passes through the eye *i;* from hence it is drawn through another eye *i*, to the central eye *k*, (*Fig.* 2,) and through the last-mentioned on to a bobbin fixed on the same shaft as the pulley *o*. The situation of the eye *k* opposite the centre of the axis of the swift, it will be observed, is indispensable to the winding off the thread; it is fixed to the end of a movable rod, which has a joint at *l*, that permits it at pleasure to be drawn forward beyond the range of the swift, for the girl in attendance to repair the thread, should it be broken. The latter circumstance, however, rarely occurs, by these improved arrangements, and the trembling motion of the bent wire at the extremity of the revolving flyer greatly assists in relieving the silk from entanglement.

The revolving flyer is the principal feature in Mr. Fanshaw's machine, and is in itself a very beautiful and no less useful invention: there are many subordinate contrivances of great ingenuity, which we have left out of the diagram to prevent confusion.

After silk has been *reeled* and *wound*, the next operations are *spinning* and *throwing*, which may be performed separately, or at the same time. The art of throwing silk was first introduced into this country in 1719, by Mr. John Lombe, who, with considerable ingenuity, and at the risk of his life, succeeded in taking a plan of a throwing machine in Sardinia, and, on his return, established a mill at Derby for conducting that operation, which had, prior to the above date, been kept a profound secret by the foreign manufacturers. From the great expense incurred in establishing the mill at Derby, application was made to Parliament to extend the term of the patent granted to Mr. Lombe, but the Legislature wisely granted him the sum of 14,000*l*., in lieu of the extension of the patent right, and upon condition that he deposited in the Tower of London a complete working model of the machine, where it now remains. Since that period many improvements have been successively made, but amongst the most complete and efficient are those introduced by Mr. Fanshaw, and patented by him a short time prior to the winding machinery already described. To avoid that confusion which would be created by the representation of the vast multiplication of pulleys, wheels, bobbins, flyers, &c., which a throwing-mill embraces, we shall confine our description to the acting parts of a single operation, leaving the reader to imagine an extensive series of them. The engravings on the following page are explanatory of these improved arrangements. *Fig.* 1 is an end view of the throwing machine; A A is the top of the frame; B the bobbin; C the top spindle; D the board which supports the spindle; E the pulley which gives motion to the set of spindles; F is the flyer to the top spindle; G the lever, which throws the pulley in and out of gear; H the lever pin or centre, on which it works; I the flyer of the bottom spindles J; K is a flutted roller, which propels the drawing roller L, and gives out the thread to be thrown by the spindle C. The silk, after being wound on the

ns P, is twisted by the revolving spindles J, which are driven by the M; the threads $g\,g$ pass separately through the eyes v, and being united at over the glass rod u, round the roller L, through the eye h, and are then



ound upon the bobbin B, the twist being effected by the revolving spindle C, ch is driven by the band F. *Fig.* 2 is a bird's-eye view of the machine; same letters referring to similar parts; R is a tooth-wheel (not shown *Fig.* 1) which drives the shaft Q, and gives motion to the rollers K; and at other end to the bevel gear N, which is connected by a rod to the motion ed that draws the bobbin backward and forward, to spread the thread formly over its surface. *Fig.* 3 is a front view of the machine for making e thread organzine or sewings, the parts having been already described above, ept the bobbins $o\,o$, which are shown in dotted lines, and are to be used in e tram is required to be made, instead of organzine. T is a catch to retain

the lever G (*Fig.* 1) in its place when the bobbins are thrown in or out of gear. *Fig.* 5 represents the end of the bobbin *b*, which is kept in its place by the small lever *w*, which lever is fastened on to the motion board *z*. *Fig.* 6 is a sectional view of *Fig.* 5. *Fig.* 7 is the spindle J, as seen in *Figs.* 1 and 3, I being a fixed flyer. *Fig.* 8 is a view of the opposite side of the pulley E, to that shown in *Fig.* 1. *Fig.* 9 is an edge view of the pulley E and lever G, as described in *Fig.* 1.

The advantages of this machine are said to be, 1st, The throwing of organzine by one process, instead of the three separate processes, as at present practised; the spinning by one machine, doubling the threads by another, and throwing by a third. 2dly. In the very great increase of speed which can be obtained. 3dly. In the easy manner in which the machine can be altered to singles, tram, organzine, sewings, or any other description of silk. 4thly. In the saving of labour, from the great quantity of spindles that can be attended to by one hand. 5thly. In the little experience required to enable "a hand" to attend the work, thereby obviating the greatest expense in throwing "mill hands."

SILVER, is the whitest of metals, and next to gold the most malleable and ductile. Under the hammer, the continuity of its parts is not destroyed until its leaves are not more than the one hundred and sixty thousandth part of an inch thick; in this state it does not transmit light. Its specific gravity is 10.474. It continues melted at 28° of Wedgewood, but a greater heat is requisite to bring it into fusion. Its tenacity is such, that a wire of one-tenth of an inch in diameter will sustain a weight of 270lbs. without breaking. Silver has neither smell nor taste; these properties, together with its brilliant whiteness, hardness and tenacity, eminently adapt it to the uses of the table; and when to these qualities is added its intrinsic value, its advantages as coin become obvious.

SILVERING. The art or act of covering certain substances, as metal, wood, paper, leather, parchment, &c. with silver, so as to give them the appearance of that metal. Silver leaf is laid on much in the same way as gold leaf, for which see GILDING.

The method of silvering copper is as follows: take of tartar and common salt, each two drachms, half a drachm of alum, fifteen or twenty grains of silver, precipitated from nitric acid by copper; mix these well together, and with the mixture rub the surface of the copper, and it will have the appearance of silver; after the loose powder is brushed off, the surface may be polished with a piece of leather. Pins are silvered by boiling them with tin-filings and tartar. The buckles, studs, plates, &c. of harness are silvered by the following cheap and easy process: take half an ounce of silver that has been precipitated from aqua-fortis by copper; muriate of ammonia and common salt, of each two ounces, and one drachm of corrosive muriate of mercury; triturate these together, and form them into a paste with water. After boiling the substances to be silvered with tartar and alum, they are to be rubbed with the above preparation, then to be made red hot, and afterwards polished. This silvering may be effected by using the argentine precipitate above mentioned, with borax and mercury, and causing it to adhere by fusion. To silver the dial-plates of clocks, the scales of barometers, thermometers, &c., and all other metallic plates of similar description, rub upon them a mixture of muriate of silver, tartar, and sea-salt, and afterwards wash off the saline matter with water. This silvering is not durable, but it may be improved by heating the article, and repeating the operation once or oftener, if it be thought necessary. The following amalgam is used for silvering the interior surface of hollow glass globes: fuse together two parts by weight of bizmuth, one part of lead, and one of pure tin, when this is nearly cold, add four parts of mercury, and fuse the whole over a gentle heat. The glass globe being thoroughly clean, introduce into it a paper funnel, which reaches to the bottom, and pour in the liquid amalgam. At a proper temperature it will adhere to the glass, which, by being turned and shaken, will thus have its interior surface completely covered, and any remainder of the amalgam may be poured out when the operation is completed.

SIZE. A kind of weak glue, used in many trades; it is made of the skins or

parings of leather, parchment, or vellum, boiled in water, and strained. mon size is made of leather, boiled in water till it becomes of a viscid con-ence. If it is wanted in painting for nicer purposes, it should be prepared aking any quantity of the shreds or cuttings of glovers' leather, and putting ch pound a gallon of water; let these be boiled for six or eight hours, lying water, so that it may not diminish to less than two quarts; then in the hot fluid through a flannel, and afterwards evaporate it, till it is of consistence of a jelly when cold. The size used in burnish gilding, and le of cuttings of parchment, is prepared much after the same manner.

LOOP. A small vessel furnished with one mast, the main sail of which is ched to a gaff above, to the mast on its foremost edge, and to a boom below. iffers from a cutter by having a fixed steeving bowsprit, and a jib-stay; the are also less in proportion to the size of the vessel.

LUICE. A frame of timber, stone, or other matter, serving to retain and the water of a river, &c., and, on occasion, to let it pass. Such is the e of a mill, which stops and collects the water of a rivulet, &c., to let it fall, ength, in the greater plenty upon the mill wheel; such also are those used ents, or drains, to discharge water off land. See TIDE-MILL, WATER-WHEEL, &c.

MACK. A small vessel, commonly rigged as a sloop or hoy; used chiefly he coasting and fishing trade.

MALT. A combination of glass with the oxide of cobalt, in the state of a fine blue powder. See ZAFFRE and COBALT.

MELTING. The operation of fusing ores, in order to separate the metals n the other minerals by which they may be combined. See IRON.

MUT, in *Agriculture*, a disease to which wheat is peculiarly liable, by which comes contaminated with a sooty looking powder, which sometimes destroys whole substance of the grain. Many contrivances called smut-machines, e been at different times invented to cleanse wheat, before grinding, from serious defect; but they have proved only partially successful in their ration, owing, we conceive, to the process simply consisting of violent agita-, which cannot be effective in removing the hollow damaged grain from the , although it may drive off much of the loose or external foulness.

NATCH-BLOCK. A block having an opening in one of its sides, wherein t the bight of a rope occasionally. This is by some termed a rouse-about k. See BLOCKS.

NOW. The frozen vapours of the atmosphere; its whiteness is owing to small particles into which it is divided, for ice, when pounded, becomes ally white.

Snow. A vessel equipped with two masts, resembling the main and fore-s of a ship, and a third mast just abaft the main-mast, carrying a sail similar to a ship's mizzen.

SNOW PLOUGH. A simple machine operating like a plough, but upon a er scale, for clearing away the snow from roads. It usually consists of rds framed together, forming an angular figure, the point of which enters snow, which is thrown by the boards to the sides of the road, leaving a fur-similar to those in a ploughed field.

SNUFF. A scented powder, the use of which is well known. The stalks obacco leaves, ground small, are the basis of all snuffs; and the various s derive their names from the whims of the manufacturers, who combine h them those odoriferous substances by which they are distinguished.

SOAP. A name given to those bodies which are compounds of the alkalies h fat and the fixed oils. The earths, and the other metallic oxides also, com-e with fat and oils, forming neutral compounds. The former have been called ps, and the latter metallic soaps. The soaps formed by the alkalies have distinguishing character of being soluble in water and alcohol. The earthy s are perfectly insoluble; and since any of the earths have a stronger attrac-for oil than the alkalies, the alkaline soaps are always decomposed by the hs. This occasions the curdy appearance when soap is used with water con-ing any earthy or metallic salt: it is from this quality that waters are said e hard.

The soaps used in the manufactures and domestic economy, are made with the fixed alkalies, combined with different kinds of fat and oil. These, in the manufacture of soap, are divided into two principal varieties, viz. hard and soft. The alkali employed for hard soap is soda, generally obtained from the different sea vegetables, and called by different names, according to the name of the plant, in different countries. Most of the algæ, but particularly the fucus and salsola, afford soda by burning. The vegetables are first dried, and then burnt in pits formed with loose stones. The earthy matter, and the soda, with some neutral salts, fuse into a crude mass, in which state it is sold. This substance is furnished in great abundance from the Highlands of Scotland, under the name of kelp, and from Alicant, in Spain, under the name of barilla. In France it is known by the name of varec; this being the name of the plant from which it is generally produced there. It is commonly, however, in this state that it comes to the soap-maker, varying frequently in its value, and often occasioning much uncertainty in its employment. It should be the first business, therefore, of the manufacturer to assay the substance from which he gets his alkali, even before he purchases it. When the exact value of the alkali is known, it is then to be treated as follows, to prepare it for mixing with the fat. The kelp, or barilla, is first to be pounded, and then mixed with one-fifth its weight of quick lime, in a large vat. These vats are generally three or four in number to each boiler. Besides these vats for the infusion of crude alkali, each of them has a cavity made under it. The bottom of each vat is even with the ground, the under cavity being sunk below, and is intended to receive the liquor which runs from a plug-hole in the upper vat, when the infusion has gone on to a certain extent. One of these vats, with its under reservoir, is sufficient for one boiling but they are generally all at work, in order to give time for the solution of the alkali from the crude mass. In charging a vat, the barilla, kelp, or potash, and sometimes mixtures of these, are first coarsely powdered and mixed with quick lime, also coarsely powdered; some water is then thrown upon these, to slake the lime. In the side of the vat some straw is first placed about the plug-hole, to prevent bits from passing through. The vat is now charged, and water poured upon the materials till it stands considerably above the solid mass; after standing several hours the plug is withdrawn, to let out the solution into the lower reservoir. The plug is now returned, and fresh water poured upon the materials. Some, or all of the first ley is now removed into one of the other lower reservoirs before the second infusion is drawn off. This is done that the soap boiler may always have at command two leys of different degrees of strength as, in the course of every boiling, he finds it necessary to use sometimes the weak, and, at other times, the strong. The number of waters to be added to the materials, depends upon the judgment of the workman, who, by his taste can tell when the water has dissolved the whole of the alkali. The ley being ready to lade out of the reservoir, which is near to the boiler, the tallow or oil first weighed, is put in. When it is sufficiently melted, the workman begins by adding the ley and stirring the mixture. The alkali and the oil soon begin to unite, forming a milky fluid. As more ley is added, and the stirring continued the liquid thickens. This is continued generally for thirty hours, and frequently more, till small portions of the soap, taken out from time to time, assume a proper consistence, which the workman, by constant experience, understands. He now adds a quantity of common salt, which has the effect of separating the watery part from the soap, which contains a portion of neutral salts, that existed in the crude alkali, especially when more than enough has been added. The fire has now to be withdrawn, and the mass left to cool. The watery part will be found at the bottom, and requires to be drawn out by a pump, which is a fixture on the side of the boiler. When this has been removed the fire is rekindled, and if the mass does not melt freely, a little water is added. As soon as the whole becomes liquid, and is made uniform by agitation with wooden poles, the fire is again withdrawn, and the mass allowed to assume a proper consistence for lading. It is laded into square moulds; these are composed of a number of strata lying one upon another, so that when the soap has become solid, each layer of frame-work can be removed, beginning at the top, and the

s cut into cakes with a small piece of brass wire at every interval; these are afterwards cut into square prismatic pieces, in which state they are Yellow hard soap is formed of similar proportions of soda and tallow :he last; but it also contains resin, and sometimes palm oil. In boiling ellow soap, the resin, oil, and tallow, are put into the boiler first. The ley pared in a similar vat, and managed, in other respects, like the white

t soap differs in its composition from hard, in containing no alkali, but h. Soft soap made with colourless fat, such as tallow, is a white unctuous ance, about the consistency of lard. If the fat be coloured, the soap par- of the same. In France, and other parts of the continent, it is generally red, sometimes with metallic oxides. Those made with yellow oil are some- coloured with indigo, which gives them a green colour. The oils employed ldom olive oil, but the cheaper oils, such as rape-oil, the oil of hempseed, d, and others. In Holland it was made with whale-oil. This oil was lden on some parts of the continent, on account of its disagreeable smell. is country, however, all the soft soaps are made with whale-oil, which a transparent mass of a yellow colour. In commerce, however, we do nd it uniform in its colour; besides the yellow part, it appears interspersed white spots, giving the whole a strong resemblance to the inside of a fig.

AP-STONE. A species of steatite. It imparts to the touch a peculiar ous feeling, like fine white soap. The soap-stone of this country is chiefly ied from the Lizard, in Cornwall, where it is found in connexion with ser- ie, to which it is nearly allied. It is much used in the manufacture of ain; also for polishing marble and other stone. It is the basis of various tics, and is combined with carmine to form rouge; it is also found very in taking grease spots out of silks, stuffs, &c.

)A. One of the fixed alkalies: it is generally procured from the ashes ine plants; indeed, its great repository is the ocean, soda being the basis salt. Combined with carbonic acid, soda is found in a mineral state in , where it abounds under the name of natron; whence it is frequently mineral alkali.

)A-WATER. See AERATED WATER.

)IUM. The metallic basis of soda, according to Sir H. Davy. See STRY.

.DER. A metallic cement for joining separate pieces of metal together on. It is a general rule, with respect to solder, that it should fuse at a emperature than the metal to be soldered. The solders of the plumber nposed of tin and lead, on account of their ready fusion. (See those) The coppersmith's solder is an alloy of copper and zinc. See those) In general, the solder is harder or softer, in proportion to the quan- copper that is in it; the greater the quantity of copper it contains, der and more difficult of fusion it becomes. Solders of different degrees ility are often required, particularly in cases where several joinings be made near to near other. The least fusible solder is employed in : place, and the others in succession, according to their order of fusibility, ubsequent joinings. If this precaution were not adopted, it would often that in soldering one joint, the heat communicated to the next thereby :ause it to become unsoldered. Before soldering, the surfaces are ren- right and clean, by scraping or filing them over; as a thin coat of oxide, foreign matter intervening, would prevent the union.

solders used for brass are usually of two kinds, denominated hard and The hard is composed of brass and zinc, varied in the proportions of xteen to two parts of brass to one of zinc. The soft solder is composed of ts brass, one of zinc, and one of tin. The brass is first melted, then the l lastly the zinc (previously well heated) is added. The mixture is then d to divide it into grains as it cools.

CIFIC GRAVITY. The weight of any body, or substance, compared ie weight of some other body which is assumed to be a standard. The

standard of comparison, by common consent and practice, is rain water, (account of its being less subject to variation, in different circumstances of ti and place, than any other body, whether fluid or solid. A cubic foot of ra water weighs 1000 ounces avoirdupois; therefore, assuming this to be the sp cific gravity of rain-water, and comparing all other bodies with it, the sa numbers which express the specific gravities of bodies, denote, at the sa time, their weight per cubic foot, in avoirdupois ounces. Hence, by referen to the tables, we are enabled to find the magnitude of any solid which is t irregular to admit of the common rules of mensuration, and also the weight any body of known magnitude which is too ponderous to be submitted to th operation of the steel-yard or balance.

Example.—Required the quantity of material in an irregular shaped block marble, weighing $4\frac{1}{2}$ tons.

Reduce the weight to ounces, and divide by the specific gravity of marble.

Hence $4\frac{1}{2}$ tons $\times$ 16 oz. $\div$ 2.838 $=$ 56.8 cubic feet.

Required the quantity of material in a statue of white Parian marble, weig ing 800 pounds.

$800 \times 16 = 12800 \div 2.838 = 4\frac{1}{2}$ cubic feet.

Again.—Required the weight of a block of Aberdeen granite, measuring 4 feet in length, 8 feet in breadth and thickness.

$43 \times 8 \times 8 = 2752.$

Then, as 1 : : 2752 : : 2.625 : 7224000 $=$ 201 tons 11 cwt. 1 qr.

The properties of specific gravity are as follows:—

1. A body immersed in a fluid will sink if its specific gravity be greater th that of the fluid; if it be less, the body will rise to the top, and be only part immersed; and if the specific gravity of the solid and fluid be equal, it w remain at rest in any part of the fluid in which it may be placed.

2. When a body is heavier than a fluid, it loses as much of its weight, wh immersed, as is equal to a quantity of fluid of the same magnitude.

3. If the specific gravity of the fluid be greater than that of the body, th the quantity of fluid displaced by the part immersed is equal to the weight the whole body. Hence, as the specific gravity of the fluid is to that of t body, so is the whole magnitude of the body to the part immersed.

Specific Gravities of Metals.

	Sp. Grav.
Antimony, in a metallic state, fused	6.624
Bismuth, cast	9.823
native	9.822
Brass, common cast	7.824
cast, not hammered	8.396
wire-drawn	8.544
Copper, cast	8.788
wire-drawn	8.878
Gold, pure, cast	19.258
the same hammered	19.362
22 carats, fine, standard	17.486
Iron, cast	7.207
bars	7.788
Lead, cast	11.352
litharge	6.300
Mercury, solid, 40° below 0 Fahr.	15.632
at 32° of heat	13.619
at 60°	13.580
at 212°	13.375
Nickel, cast	7.807

	Sp. G
Platina, crude, in grains	15.
purified	19.
the same hammered	20.
„ rolled	22.
„ wire-drawn	21.
Silver, cast, pure	10.
„ „ hammered	10
French coin	10
shilling (George III.)	10
Steel, soft	7
hardened, but not tempered	7
tempered, but not hardened	7
tempered and hardened	7
Tin, pure Cornish	7
Malacca, fused	7
Tungsten	6
Uranium	6
Wolfram	7
Zinc, in its usual state	6
pure and compressed	7

Specific Gravities of Woods.

	Sp. Grav.
er	.800
	.845
ch	.852
, Dutch	.912
ipechy	.913
ar, American	.561
Indian	1.315
Palestine	.613
rry-tree	.715
on	.726
k	.240
ress	.644
ny, Indian	1.209
r	.695
	.671
ert	.600
yellow	.657
white	.569
el	.600
iper	.556
non-tree	.703

	Sp. Grav.
Lignum-vitæ	1.333
Lime-tree	.604
Logwood	.913
Mahogany	1.063
Maple	.750
Mulberry	.897
Oak, heart of, 60 years old	1.170
Olive-tree	.927
Orange-tree	.705
Pear-tree	.661
Pomegranate-tree	1.354
Poplar	.383
Plum-tree	.755
Quince-tree	.705
Sassafras	.482
Vine	1.327
Walnut	.671
Willow	.585
Yew, Spanish	.807
Dutch	.788

Specific Gravities of Stones, Earths, &c.

aster, yellow	2.699
bergris	.926
anthus, long	.909
short	2.313
estos, ripe	2.578
starry	3.073
ax	1.714
k	2.000
k, British	2.784
, Cannel	1.270
Newcastle	1.270
Staffordshire	1.240
Scotch	1.300
r's stone	2.111
ry	4.000
, black	2.582
white	2.594
, flint	2.933
bottle	2.732
green	2.642
Leith, crystal	3.189
ite, Aberdeen, blue kind	2.625
Cornish	2.662
Egyptian, red	2.654
beautiful red	2.761
Girardinor	2.716
violet, of Gyromagny	2.685
Dauphiny, red	2.643
" green	2.684
" radiated	2.668
Semur, red	2.638
Bretagne, grey	2.738

Granite, Bretagne, yellowish	2.619
Grindstone	2.143
Gypsum, opaque	2.168
semi-transparent	2.306
Hone, white, razor	2.876
Jet, a bituminous substance	1.259
Lime-stone, green	3.182
white fluor	3.156
compact	2.720
Manganese	7.000
Marble, Biscayan, black	2.695
Brocatelle	2 650
Carrara, white	2.717
Egyptian, green	2.668
Italian, violet	2.858
red	2.724
Porcelain, China	2.385
Porphyry, red	2.765
green	2.676
Salt	2.130
Serpentine, opaque, green, Italian	2.430
Slate, common	2.672
Stalactite, opaque	2 478
Stone, Bristol	2.510
Portland	2.570
Pumice	.915
Purbeck	2.601
rag	2.470
Sulphur, native	2.033
melted	1.991
Talc, Muscovy	2.792

Specific Gravities of Liquids.

	Sp. Grav.		Sp. Grav.
Acetic acid	1.007	Oil of linseed	.940
Alcohol, commercial	.837	olives	.915
highly rectified	.829	poppies	.924
Ammonia, liquid	.897	rape-seed	.919
muriate of	1.453	turpentine, essential	.870
Beer, pale	1.023	whales	.923
brown	1.034	Spirits of wine, commercial	.837
Benzoic acid	1.018	highly rectified	.829
Cyder	1.018	Sulphuric acid	1.841
Ether, acetic	.866	highly concentrated	2.125
muriatic	.730		
nitric	.909	Turpentine, liquid	.991
sulphuric	.739	Vinegar, distilled	1.010
Fluoric acid	1.500	Water, rain	1.000
Formic acid	.994	distilled	1.000
Milk of Cows	1.032	sea	1.026
Muriatic acid	1.194	Wine, Burgundy	.992
Nitric acid	1.271	Bordeaux	.994
highly concentrated	1.583	Champaigne, white	.998
Oil of almonds, sweet	.917	Canary	1.033
cloves, essential	1.036	Constance	1.082
cinnamon, essential	1.044	Madeira	1.038
filberts	.916	Malaga	1.022
hemp-seed	.926	Port	.997
lavender, essential	.894	Tokay	1.054

Specific Gravities of Resins, Gums, Animal Substances, &c.

Aloes, socotrine	1.380	Gunpowder, in a loose heap	.836
Ambergris	.926	shaken	.932
Assafœtida	1.328	solid	1.745
Bark, Peruvian	.785	Honey	1.450
Butter	.942	Indigo	.769
Camphor	.989	Ivory	1.826
Copal, Chinese	1.063	Lard	.948
Fat, beef	.923	Madder-root	.765
mutton	.924	Mastic	1.074
veal	.934	Myrrh	1.360
hog's	.967	Olibanum	1.173
Galbanum	1.212	Opium	1.336
Gamboge	1.222	Spermaceti	.943
Gum Ammoniac	1.207	Sugar, white	[illegible]
Arabic	1.452	Tallow	.942
Scammony of Aleppo	1.235	Wax of bees, white	.969
„ of Smyrna	1.274	yellow	.965
tragacanth	1.316	Shoemakers'	.897

Gases.

In the following Table, the specific gravities of the principal gases will be given as they correspond with the specific gravity of atmospheric air, which is supposed to be about 1.000.

Atmospheric, or common air	1.000	Carbonic acid	1.520
Ammoniacal gas	.500	oxide	.960
Arsenical hydrogen gas	.529	Carburetted hydrogen	.491
Azote	.969	Chlorine	.470

	Sp. Grav.		Sp. Grav.
onic gas	3.389	Oxygen, mean	1.014
ic vapour	2.111	Phosphuretted hydrogen . .	.870
. . . .	1.806	Steam	.690
. . . .	2.409	Sulphuretted hydrogen . .	1.777
. . . .	2.371	Sulphurous acid	2.193
cid gas	3.574	Vapour of Alcohol	2.100
. . . .	.074	absolute alcohol .	1.613
cid gas	4.443	hydriotic ether .	5.475
vapour	.948	iodine	8.620
d gas	1.278	muriatic ether . .	2.219
. . . .	1.094	oil of turpentine .	5.013
gas	2.427	sulphuret of carbon	2.645
de	1.614	sulphuric ether .	2.586

ding, it may be necessary to remark, that all bodies expand by heat by cooling; but the contraction and expansion, by the same temperature, is very different in different bodies. Water, when 60 to 100 degrees, increases its volume nearly one sixty-seventh of rcury, one two-hundred and forty-third part; and many substances It is therefore proper, in ascertaining the specific gravities of bodies, icularly the temperature.

CLES. An optical instrument consisting of two lenses set in a light xtremities of which are made elastic, so as to retain, by a slight nst the sides of the head, the instrument in its place, which is pon the nose of the wearer. The use of spectacles is to counteract in the organs of vision; and as these differ in their nature, ry in their properties. Those with convex lenses serve to counter- s arising from the too great flatness of the eye, by giving the rays gree of convergency sufficient to make them meet exactly at the re, therefore, generally proper for elderly persons. On the contrary, people use concave lenses, to prevent the rays from converging so ecause the eyes of such persons being too round and protuberant, a convergency to the rays, and cause them to meet before they ina, which defect is remedied by glass of a suitable concavity.

CETI. A substance obtained from the oil found in the head of s of whale, but chiefly from the *physeter macrocephalus.* Though fat and wax, it differs from them in several properties. It is of a —soft, white, and brilliant; melts at 113°; and by raising the heat tilized with little change, though by repeated distillation it is It burns with a clear flame. A property distinguishing it from solubility in alcohol and ether, though it is but sparingly soluble It dissolves more rapidly and abundantly in warm ether, from ipitates when cool: oil of turpentine acts upon it in a similar rmaceti is found in a large triangular trunk, four or five feet deep, elve long, filling almost the whole cavity of the head, and seeming different from the proper brain of the animal. The oil is separated ping. In this state it has a yellow, unctuous appearance, and is ngland in barrels. An ordinary sized whale, it is said, will yield welve large barrels of crude spermaceti. The mode of purifying way is as follows:—the mass is put into hair or woollen bags, between plates of iron, in a screw-press, until it becomes hard and then broken into pieces, and thrown into boiling water, where it e impurities which rise to the surface, or sink to the bottom, are or separated from it. After being cooled, and separated from the t into fresh water in a large boiler, and a weak ley of the potash dded to it by degrees. This part of the process is thrice repeated, e whole is poured into coolers, when the spermaceti concretes into ransparent mass, which, on being cut into small pieces, assumes

the flaky appearance which it has in the shops. Some adulterate it with wax but the deceit is discovered, either by the smell of the wax, or by the dulness of the colour. Some also sell a preparation of oil taken from the tail of the whale instead of that from the brain; but this kind turns yellow as soon as exposed to the air. Indeed, it is apt, in general, to grow yellowish, and to contract a rancid, fishy smell, if not carefully secured from the air. The more perfectly it has been purified at first, the less susceptible it is of these alterations; and after it has been changed, it may be rendered white and sweet again by steeping it afresh in a ley of alkaline salt and quicklime. It melts in a small degree of heat, and congeals again as it cools.

The great use of spermaceti is for making candles, and it is also employed in medicine. Spermaceti candles are of modern manufacture: they are made smooth, with a fine gloss, free from rings and scars, superior to the finest wax candles in colour and lustre; and, when genuine, leave no spot or stain on the finest silk, cloth, or linen.

SPHERE. A solid contained under one uniform round surface, such as would be formed by the revolution of a circle about the diameter thereof.

SPHEROID. A solid body approaching the figure of a sphere, though not exactly round, but having one of its diameters longer than the other.

SPINDLE. A term synonymous with axis. In machinery where several axes occur, it is usual to denominate the subordinate or smaller axes spindles, as in cotton-spinning, &c.

SPINET. A musical instrument of the piano-forte kind. The latter, by its improved tones and construction, has superseded the manufacture, and almost wholly banished the use of the former. See Piano-forte.

SPINNING. The art of combining animal or vegetable fibres into threads, by twisting them together, as in cotton, silk, wool, flax, hemp, &c. See those articles.

SPONGE. A marine production of a remarkably porous and absorbent nature. Its property of readily imbibing almost as great a volume of water as its own bulk, and as readily parting with it by compression, renders it of great utility. The best is of a light colour, free from stones and other impurities, very soft and elastic, and the pores or holes small. It is chiefly obtained from the Mediterranean, about the shores of Turkey and the Archipelago, where it grows upon the rocks at considerable depths under water. To bleach sponge and render it white, it is soaked repeatedly in fresh water, changing the fluid several times a day; and at the end of five or six days it will be ready for bleaching. If the sponge contains pieces of shells, chalk, &c., which cannot be extracted without tearing it, the sponge must be soaked for twenty-four hours in muriatic acid, diluted in twenty times as much water, which will cause an effervescence to take place, and carbonic acid to be liberated, when the shells and chalk will be dissolved. After this the sponge must be carefully washed in fresh water, and then immersed for seven or eight days in a weak solution of sulphuric acid (specific gravity 1.024), occasionally pressing it out dry. After it has again been perfectly washed and cleaned, it may be sprinkled with a little rose-water, to give it a pleasant smell.

STARCH. A well-known substance extracted from wheaten flour, by washing it in water. All farinaceous seeds afford this substance in a greater or less degree; but it is most easily obtained from the flour of wheat, by moistening any quantity with a little water, and kneading it with the hand into a tough paste; this being washed with water, by letting fall upon it a very slender stream, the water will be rendered turbid as it runs off, in consequence of the fecula or starch which it extracts from the flour, and which will subside when the water is allowed to stand at rest. The starch so obtained, when dried in the sun, or by a stove, is usually concreted into small masses, which have a fine white colour, scarcely any smell, and very little taste. If kept dry, starch in this state continues a long time uninjured, although exposed to the air. The inferior and refuse wheat is usually employed for manufacturing common starch; but when the finest starch is required, good grain must be used. This, being well cleaned, and sometimes coarsely bruised, is put into wooden vessels

...er, to ferment: to assist the fermentation, the vessels are exposed to
...t heat of the sun, and the water is changed twice a day, during eight
...days, according to the season. When the grain bursts easily under
... and gives out a milky white liquor when squeezed, it is judged to be
...ly softened and fermented. In this state the grains are taken out of
... by a sieve, and put into a canvass sack, and the husks are separated
...d off by beating and rubbing the sack upon a plank: the sack is then
... tub filled with cold water, and trodden or beaten till the water
...milky and turbid, from the starch which it takes up from the grain.
...metimes swims upon the surface of the water, which must be care-
...oved, the water is then run off through a fine sieve into a settling
...d fresh water is poured upon the grains, two or three times, till it will
... any more starch, or become coloured by the grain. The water in
... vessels, being left at rest, precipitates the starch, which is held sus-
...nd to get rid of the saccharine matter, which was also dissolved by
... the vessels are exposed to the sun, which soon produces the acetous
...on, and takes up such matter as renders the starch more pure and
When the water becomes completely sour, it is poured gently off from
..., which is washed several times afterwards with clean water, and at
...ed to drain upon linen cloths, supported by hurdles, and the water
...ugh, leaving the starch upon the cloths, in which it is pressed and
... extract as much as possible of the water; and the remainder is
... by cutting the starch into pieces, which are laid up in airy places,
...or of plaster, or of slightly burnt bricks, until it becomes completely
... all moisture, partly from the access of warm air, and partly by the
...ing the moisture. In winter time, the heat of a stove must be
... to effect the drying. Lastly, the pieces of starch are scraped to
... outside crust, which makes inferior starch, and these pieces are
...to smaller pieces for sale.

...M. The term generally employed to designate water in its elastic form,
... the temperature of 212°. It is at present applied to many economical
... as well as in various manufactures, independent of its important
...the steam-engine. In order to make water boil, the fire must be
... the bottom or sides of the vessel which contains it: if the heat be
... the surface of the water, it will waste away without boiling, because
...cial particles, by imbibing the heat necessary to render them elastic,
...hout agitating the rest; but when applied to the lower surface of the
... bubbles which are formed at the bottom rise, and give off their heat
...umbent mass, and then disappear by collapsing: the distances which
... before collapsing increase as the water continues to warm further
..., till it breaks out into boiling on the surface. If the handle of a
... grasped with the hand, a tremor will be felt for some little time
...ing, arising from the little succussions which are produced by the
... of the bubbles of vapour. This is much more violent, and is really
...ble phenomenon, if we suddenly plunge a lump of red hot iron into
... cold water, when, if the hand be applied to the side of the vessel, a
...t tremor is felt, and sometimes strong thumps; these arise from the
... of very large bubbles. The great resemblance of this tremor to the
...perienced during the shock of an earthquake has led many to suppose
...ast are produced in the same way; and the hypothesis is by no means
...

...lowing propositions have been generally assumed by certain authorities
... data.—

...ic inch of water forms a cubic foot of steam, when its elasticity is
... inches of mercury.

... pound of Newcastle coal will convert seven pounds of boiling water
...

...me required to convert a given quantity of boiling water into steam
... that required to raise it from the freezing to the boiling point, or
... 212°, supposing the supply of heat to be uniform.

4. When a quantity of water is exposed to a given temperature, the quantity of steam formed in a given time will be as the surface, all other things being equal. The quantity will also be jointly as the force of vapour answering to each degree of heat, and the surface. The depth of water evaporated in a given time will be as the force of vapour, whatever the surface, if the mass be uniformly of the same temperature. When the force of vapour is 30 inches, and the temperature at 212°, this degree being just preserved only, the depth evaporated is 1.3 inch in one hour.

5. When a quantity of water is raised to the boiling point, or 212°, it requires as much heat to give it the elastic form as would raise the same water 900° higher if its volume were not changed by the heat; that is, if it could be prevented from expanding, its temperature would become 1112° with the same quantity of caloric; thus, agreeably to fact 3, the heat required to convert water of 212° in to steam is six times that required to raise the temperature from 32° to 212°. See also Steam-Engine, *power of.*

STEAM CARRIAGES.—Under this designation is to be understood all kinds of locomotive vehicles, propelled on the common roads, by other than animal force.

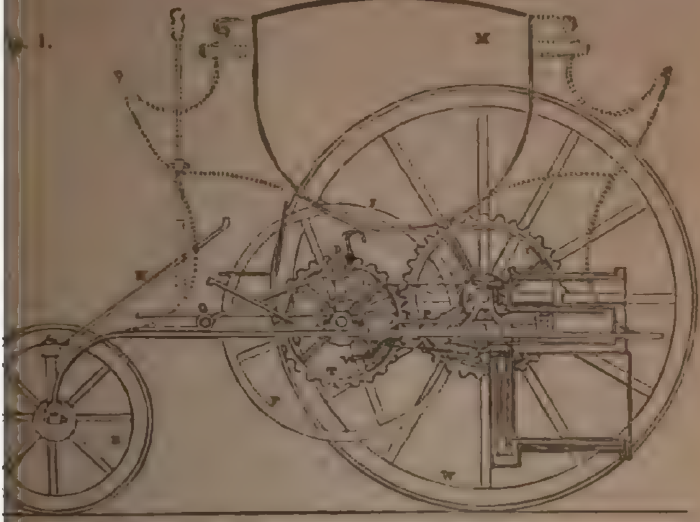
In the case of steam carriages used upon *rail*-roads, the structure of one is so dependent upon the other, that the former may be regarded as the moving, and the latter the stationary part, of the same machine. Whether the distinction thus attempted to be drawn is not in some degree applicable to both classes of locomotives, might be disputed; but there are other marked differences between them, which have induced us to treat them separately. The common road locomotives require to *perfect* them a higher degree of mechanical still than those on the rail; because they have not, like the latter, a level and unyielding surface to roll upon, but one that is full of asperities, and easily penetrable, hence increasing in a great degree the difficulties of construction. The former, likewise, now belong to a history of the past; while the latter form the glories of the present day. We therefore refer the reader to the Article Railway, for all locomotives that are designed for that species of way.

The merit of the first suggestion of steam carriages has been attributed to various individuals; but the probability is, that the idea of applying the steam engine for the purpose of locomotion is coeval almost with its first invention. Thus Savery from having considered its possibility, and Dr. Robison for having suggested it to Watt, have by some been regarded as the inventors. Mr. Watt, however, never built a steam engine; and it is said that he retained up to the period of his death, the most rooted prejudices against the use of *high* steam. Indeed, he says himself, "I soon relinquished the idea of constructing an engine on this principle, from being sensible it would be liable to some of the objections against Savery's engines, viz. the danger of bursting the boiler, and that a great part of the power of the steam would be lost, because no vacuum was formed to assist the descent of the piston." It was, however, the sagacity of two Cornish engineers, Trevithick and Vivian, which enabled them to perceive in the excessive force exerted by high steam, (and which alarmed Watt,) that very power which was indispensable to the propulsion of locomotive carriages; as it dispensed with the use of a condenser, and all its cumbrous appendages.

Previous to the year 1802, animal power was the only one known or in use for the moving of carriages; at that period, the above mentioned engineers obtained a patent for an improved steam engine, which was the first of the high pressure kind, and is thus characterized by the eloquent Mickleham. "It exhibits in construction the most beautiful simplicity of parts, the most sagacious selection of appropriate forms, their most convenient and effective arrangement and connexion; uniting strength with elegance; the necessary solidity with the greatest portability; possessing unlimited power with a wonderful pliancy to accommodate it to a varying resistance: it may indeed be called "The Steam Engine." The specification of the patent, after describing this engine, proceeds to show its application, "to give motion to wheel carriages of every description," by suitable drawings and explanations. From a copy of

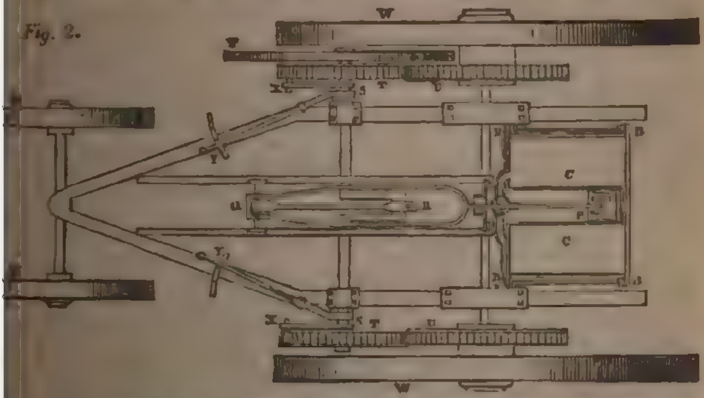
ocument we derive the following account of the first steam carriage which onstructed.

. 1.



Trevithick and Vivian's Steam Carriage.—Patent 1802

Fig. 2.



. 1, is a vertical section, and *Fig.* 2, a plan, showing the principal arrange- of the first steam carriage. "At B B, is the case, having therein the , with its fire place and flues. At P Q, is the piston rod, forked to admit od of the crank R; the said rod drives a cross piece at Q backward and d between guides; and this cross-piece, by means of the bar Q R, gives n to the crank with its fly F, and to two wheels T T upon the crank axis, lock into two correspondent wheels U upon the naves of the large wheels carriage itself. The wheels T are fixed upon round sockets, and receive motion from a striking box or bar S X, which acts upon a pin in each . S Y are two handles, by means of which either of the striking boxes S X thrown out of gear, and the correspondent wheel W by that means dis-

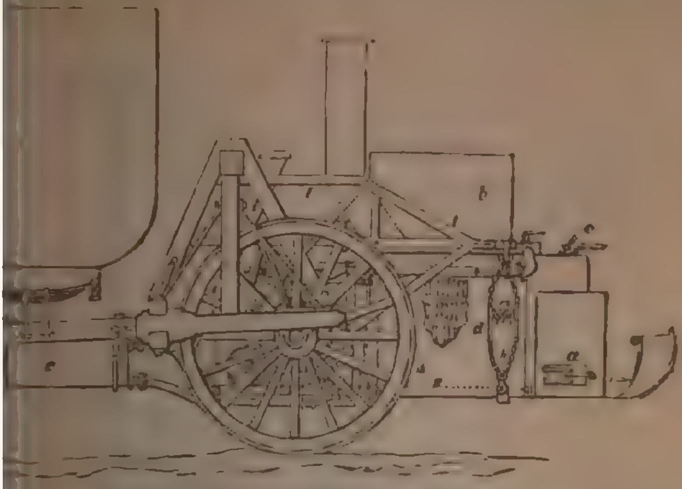
connected with the first mover, for the purpose of turning short, or *admitting a backward motion of that wheel when required; but either of the wheels* w, *in case of turning, can be allowed considerably to overrun the other without throwing* six *out of gear*, because the pin can go very nearly round in the forward motion before it will meet with any obstruction. The wheels U are most commonly fixed upon the naves of the carriage-wheels w, by which means a revolution of the axis itself becomes unnecessary, and the outer ends of the said axis may consequently be set to any obliquity, and the other part fixed or bended, as the objects of taste or utility may demand. *The fore-wheels are applied to direct the carriage by means of a lever* N; *and there is a check lever which can be applied to the fly, in order to moderate the velocity of progression when going down hill.* In the vertical section is shown a springing lever, having a tendency to fly forward. Two levers of this kind are duly and similarly placed near the middle of the carriage, and each of them is alternately thrown back by a short bearing lever upon the crank axis, which sends it home into a catch at the end, and afterwards releases it when the bearing lever comes to press upon V, in which case the springing lever flies back. A cross bar, or double handle is fixed upon the upright axis of the cock, from each end of which said cross bar proceeds a rod *p q*, which is attached to a stud *q*, that forms part of the spring lever. This stud has a certain length of play, by means of a long hole or groove in the bar, so that when the springing lever is pressed up, the stud slides in the groove without giving motion to *p*. When the other springing lever is disengaged, it draws the opposite end of the handle, and causes *p* to draw the long hole at *q* up to its bearing against the stud, ready for the letting off of that first-mentioned springing lever. When this last mentioned lever comes to be disengaged, it suddenly draws *p* back, and turns the cock one quarter turn, and performs the like office of placing the horizontal rod of the other extremity of the handle ready for action by its own springing-lever. *These alternations perform the opening and shutting of the cock*, and to one of the springing levers is fixed *a small force-pump w, which draws hot water from the cask by the quick back-stroke, and forces it into the boiler by the stronger and more gradual pressure of a lever on the crank axis.* It is also to be noticed that *in certain cases* we make the external periphery of the wheels W uneven, by projecting heads of nails or bolts, or cross grooves, or *fittings to railroads*, when required; and that *in cases of hard pull* we cause a lever, bolt, or claw, to project through the rim of one or both of the said wheels, so as to take hold of the ground; but that *in general the ordinary structure or figure of the external surface of these wheels will be found to answer the intended purpose.* And, moreover, we do observe and declare, that the power of the engine, with regard to its convenient application to the carriage, may be varied, by changing the relative velocity of rotation of the wheels W compared with that of the axis S, by shifting the gears or toothed wheels for others of different sizes, properly adapted to each other in various ways, which will readily be adopted by any person of competent skill in machinery. The body of the carriage M may be made of any convenient size or figure, according to its intended uses. And, lastly, we do occasionally use bellows to excite the fire, and the said bellows are worked by the piston-rod or crank, and may be fixed in any situation or part of the several engines herein described, as may be found most convenient."

A carriage was built soon after the grant according to the construction above given, and exercised before the public for a considerable time in the neighbourhood of the present site of Euston Square, London. Succeeding patentees, it will be observed, have availed themselves of the judicious arrangement of these ingenious projectors.

Such was the indifference of the public to inventions of the kind, that nineteen years elapsed before another steam carriage for the common road was brought out, which was the subject of a patent granted to Mr. Julius Griffith in 1821; and this carriage, we are informed, was chiefly designed by foreigners.

At *a* is the furnace, supplied with fuel from a receptacle *b*. At *c* are two handles, one to open the feeding door, and the other to operate upon a damper. The boiler is at *d* in a double case packed with non-conducting materials. It

...nsists of tiers of horizontal tubes. Connected by bolts and straps to the ...f the carriage, is a reservoir of water *e*, which is drawn out by a force-...p *f*, and by the return stroke injected into a pipe *g* at the bottom of the



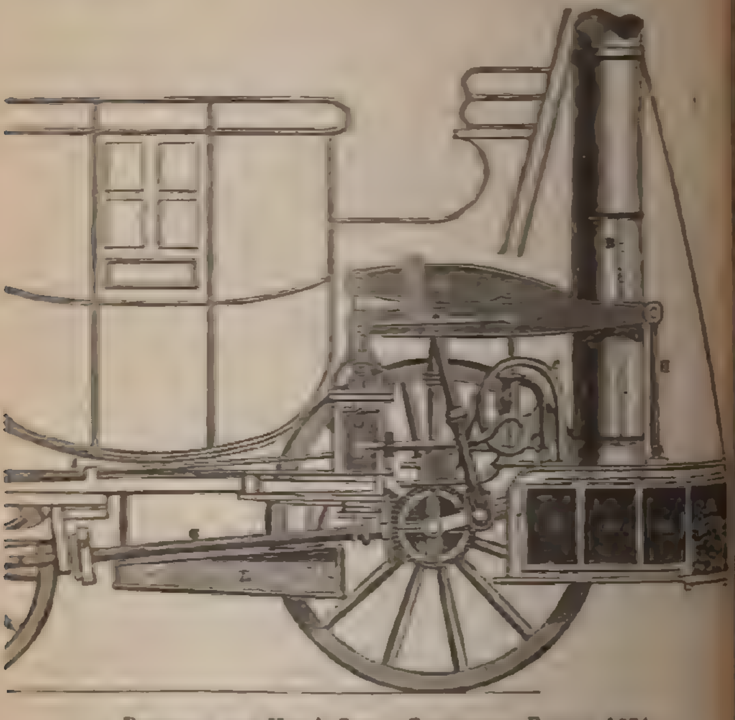
Griffith's Steam Carriage.—Patent 1821.

...whence it is distributed into the lowermost range of tubes, and from ...the next above, the uppermost row being employed as steam reservoirs, ...living the waste heat as it passes to the chimney, so as to increase the ...force of the vapour before it proceeds along the steam pipe *h* to the ... whence, after having given motion to the pistons, it is conducted by a ...to the condenser *i*, which consists of a number of flattened thin metal ...posed to the cooling influence of the air. The power of the engines is ...icated from the piston rods to the running wheels of the carriage ...the means of sweep-rods, (one of which is brought into view at *j*,) the ...ds of which are provided with driving pinions and detents, which ...upon toothed gear fixed to the hind carriage wheel axle. The object of ...hanism, (which is of foreign invention, and denominated an Artzberger,) ...p the driving pinions always in gear with the toothed wheels, however ...ne and other machinery may vibrate, or the wheels be jolted upon ...round. In order that the engines and steam apparatus may not suffer ...concussions of the latter, they are suspended by slings at *k* to a strong ...aing *l l*, and to give the suspending chains some degree of elasticity, ...ical springs are introduced between them, as shown at *m*.

...uiding of the carriage is effected by means of levers which turn round ... of the fore wheels, so as to present the latter in the line of direction ... The axles are supported in a vertical frame, which is made to turn ...ally, by means of a guide wheel, on the top of a spindle, the lower ... of which carries a pinion that takes into an internal toothed wheel

... not aware that Mr. Griffith's carriage ever made any public demon-... of its working powers; but Mr. A. Gordon states that the chief ... which Mr. Griffith had to contend with, was the liability of having all ...blown out of the tubes, by the pressure of the steam on the lower part; ...ion having been made for allowing the water to return, or for main-... equilibrium of pressure. Notwithstanding the failure of this attempt,

[illegible]



Burstall and Hill's Steam Carriage.—Patent 1824.

" A is the place for fuel, and $a\ a\ a$ are parts of the flue, as seen in section, the top being formed into a number of shallow receptacles for water in a state of being converted into steam. B is the chimney; at D are two cylinders, one behind the other, which are fitted up with pistons and valves in the usual way for the alternate action of steam above and below the pistons. The boiler is suspended on springs; and the steam is conveyed from it to the engines, through the helical pipe c, which has that form given to it to allow the vibration of the boiler, without injury to the steam joints. E is the cistern containing water in one stage, say 50 to 80 gallons, and made to sustain a pressure of about [illegible] pounds to the square inch. At e are one or more air-pumps, which are worked by the beams F F of the engines, and are used to force air into the water vessel, that its pressure may drive out, by a convenient pipe, the water into the boiler as it may be required. The two beams are connected at one end with the piston rods, and at the other with the rocking standards H H; $g\ g$ are connecting rods attached to two cranks, giving a continued rotatory motion to the wheels, without the necessity of a fly-wheel. The four coach wheels are attached to the axles nearly as in common coaches, except that there is a ratchet wheel formed upon the back part of the nave, with a box wedged into the axle, containing a spring pall, causing the wheels to be impelled when the axle

elves, and at the same time allowing the outer wheel, when the carriage cribes a curve, to travel faster than the inner one, and still be ready to give the impulse of the engine as soon as it comes to a straight course.

The patentees have another method of performing the same operation, with further advantage of backing the coach when the engines are backed. In plan, the naves are cast with a recess in the middle, in which is a double elled clutch, the inside of the nave being formed to correspond. The clutches simultaneously acted upon by connecting levers, and springs, and which, ording as they are forced to the right or left, will enable the carriage to be ved forward or backward. To the fore nave are fixed two cylindrical metal gs, round which are two friction bands, to be tightened by a lever convenient the foot of the conductor, and which will readily retard or stop the coach en descending hills. K is the seat of the conductor, with the steering wheel n the front, which is fastened on the small upright shaft 1, and turns the two rel pinions 2, and the shaft 3, with its small pinion 4, which, working into a zontal rack on the fore carriage, places the two axles at any required angle, centre of motion being the perch-pin I."

The patentees built a steam carriage upon the foregoing plan, but with merous alterations and modifications. Their success in demonstration was partial. Like other locomotionists who followed them, something was always uiring to be altered, to overcome new difficulties introduced by previous provements; but they had the good sense to retire from the undertaking hout very heavy pecuniary loss, and with undiminished reputation as chinists; the problem not having been solved, *satisfactorily*, by any succeed- inventors.

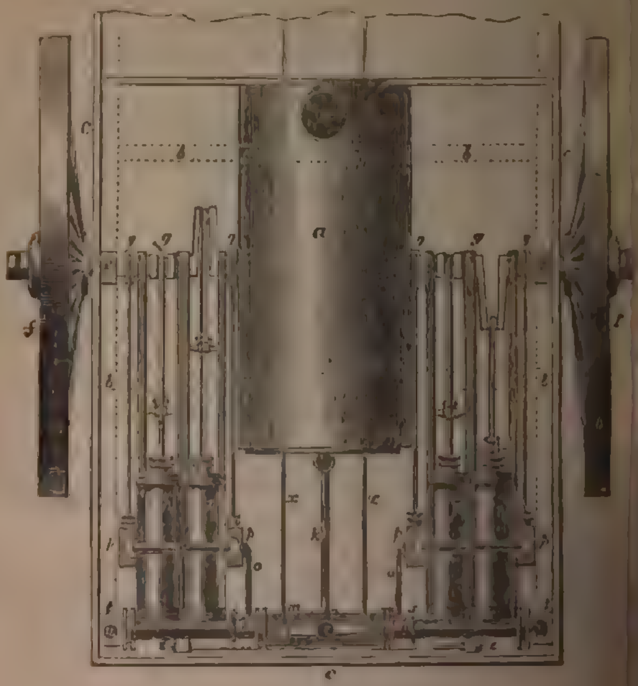
Mr. W H. James, of Birmingham, gave the subject of steam carriages much ious attention for several years, in the course of which, and through the aid Mr James C. Anderson, he constructed several in succession. The first of m acted as well, or nearly so, as those which followed.

Mr. James caused the engines and their frame-work to vibrate altogether h the crank shafts as a centre, and connected these engines to the boiler exit passages, by means of hollow axles moving in stuffing boxes, which, ether with the body of the carriage, were suspended upon springs bolted to axletrees.

Fig. 1, in the following cut, exhibits a plan of the machinery of a carriage, as lied to the hind wheels. At *a* is the boiler; which consisted of a series of ular tubes of equal capacity and diameter, placed side by side, and bolted ether, so as to form by their union a long cylindrical boiler, as shown in the ure. A full description of this generating apparatus having been already en under the article Boiler, we shall not here enlarge upon it. The frame s four vertical supports *e e e e* connected to it, and from these beams are nded over the boiler, which is suspended to them; and they also carry by able bearings the body of the vehicle, which it is unnecessary to explain.

The axles of the running wheels *f f* are connected in one piece with each of crank shafts *g g*, by which one wheel is made to revolve independently of other. Each of these engines has two cylinders *h h*, which operate by their on rods upon the cranks; to these separate engines steam is applied from boiler *a a*, by means of the pipe *k*, which enters at the stop-cock *l* into the m-box *m*; from this box the steam passes into the pipes *n n*, which move m-tight through stuffing-boxes; from thence the steam proceeds through pipes *o o o* to the slide boxes *p p p*, the slides being worked by eccentrics *q*, on the crank shafts, in the usual manner, and thence to the cylinders. exhaustion pipes *r r* lead into hollow axles *n n*, in which there are par- ons *s s*, to separate the steam from the exit passages, which pass through the hollow axles to the boxes *t t*, from which there are pipes *u u* leading to the mney *v*, where it is thrown off to increase the draught, and combustion of the fuel. rods *x x* are attached to the fore axle of the running wheels, and also to the handles of the cock *l*, so that the fore axle and the cock move simultaneously, parallel to each other; *z z* represent part of the frame-work extended, for

tying the engine together by means of a bolt, and so as to allow the body of the carriage to have a slight lateral motion upon its springs, independently of the engines, by means of the hollow axles sliding longitudinally through the stuffing boxes.



W. H. James's Steam Carriage.—Patent 1824.

In 1832 Mr. James took out another patent, the chief features in which were a high pressure boiler of a novel description; being formed of a horizontal tier of cast-iron plates ingeniously cast with tubular cavities in the body of the metal, and throughout its area. These cavities hold the water to be vaporized, which is constantly made to flow throughout the tier, by a hydraulic apparatus, which the inventor denominates a "heart-pump." The fire operates upon the entire bottom surface of each water-plate, and the steam is collected in the highest plate, to which, in addition to the usual appendages of a steam carriage, is a steam pipe leading to a trumpet, which is sounded by the means of a lever operating upon a valve at the induction orifice.

The performances of Messrs. James & Co.'s carriages were not much dissimilar to those of other locomotionists of like extent of experience. The practicability of the scheme in a mechanical point of view, we had ample demonstrations of; and on one occasion we were propelled at the rate of fifteen miles an hour for several miles together. But the undertaking was (commercially speaking) unsuccessful, and was therefore discontinued.

In 1824 the late Mr. David Gordon obtained a patent for steam carriages to run on common roads.

Mr. David Gordon's carriage ran upon three wheels; one in front to steer by, and two behind to bear the chief weight. Each of the wheels had a separate

-e ends of which had their bearings upon parallel bars, the wheels rolling rpendicular position.

e fore part of the carriage were placed the steam engines, consisting of cylinders, in a horizontal position, but vibrating upon trunnions: the rods of these engines gave motion to an eight-throw crank, two in the for the cylinders, and three on each side, to which were attached the rs; by the revolution of the crank, these propellers or legs were succes- orced outwards, with the feet of each against the ground in a backward , and were immediately afterwards lifted from the ground by the on of another crank, parallel to the former, and situated at a proper dis- rom it on the same frame. To the lower ends of these propelling rods tached the feet, of the form of segments of circles, and made on their de like a short and very stiff brush of whale-bone, supported by inter- ron teeth. These feet pressed against the ground in regular succession, d of rolling, circular motion, without digging it up. The guide had er of lifting these legs off the ground at pleasure, so that, in going down n the gravity was sufficient for propulsion, nothing but a brake was put osition to retard the motion, if necessary. If the carriage was proceeding level, the lifting of the propellers was equivalent to the subtraction of r, and soon brought it to a stoppage; and in making turns in a road, e had only to lift the propellers on one side of the carriage, and allow rs to operate alone, until the curve was traversed.

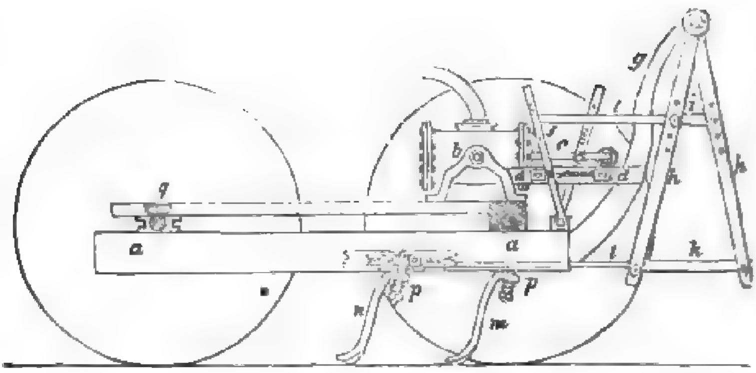
DAVID GORDON'S STEAM CARRIAGE.—PATENT 1824.

ove engraving represents a side elevation of the machine; the front of ge being cut off as useless to our object, and as occupying valuable At *a* is the end of the boiler; *b* the flue; *c* an apartment for the

engineer to attend the fire and regulate the machinery, which apartment contains a store of water, coke, &c.; *d* external connecting rod (one on each side of the carriage), by which the driving cranks of the propellers actuate the small lifting cranks within the carriage; *e* being the axis of the driving cranks, and *f* the axis of the lifting cranks; *p p* are the propellers; *s s* straps by which the propellers are lifted from the ground by the alternations of the crank.

It was in the year 1825, that Mr. Goldsworthy Gurney, a medical gentleman of London, commenced his career in locomotion; and being liberally supported by capitalists, he built a number of steam carriages; which during several years were occasionally brought out of the factory, and experimented with on the public roads; but without attaining that degree of success, in an economical point of view, which the public were at first led to believe had been effected. The first attempt made by Mr. Gurney was, properly, that of producing a steam generator of superior efficacy, which our readers will find fully described and illustrated in the Boiler. The specification of his patent is thus reported in the London Journal of Arts and Sciences.

"The mode of propelling carriages on roads and railways, proposed by the patentee, is by the agency of moving legs, or crutches, striking out under the carriage, the lower ends of which legs are intended to bear against the ground as a resistance, and, being forced backwards by the power of machinery, cause the carriage to move forward in the opposite direction. Similar contrivances to this have been repeatedly suggested. The patentee, therefore, is to be considered as merely adopting this plan as one that he considers most convenient; and claims as his invention *simply the guide rollers* attached to the legs, upon which the carriage moves forward. The annexed figure represents the side of the carriage running upon ordinary wheels, with the steam-engine by which its propelling legs and other mechanism are to be moved; *a a* is the perch or main beam of the carriage; *b* the working cylinder of the steam-engine, which in this instance lies nearly horizontal, and is supported in standards upon pivots; *c* is the piston rod of the engine, with a small guide roller running upon the stationary block *d*. The piston rod is attached by a joint to the vibrating lever *e*, from which lever a chain extends over small pullies, let into the

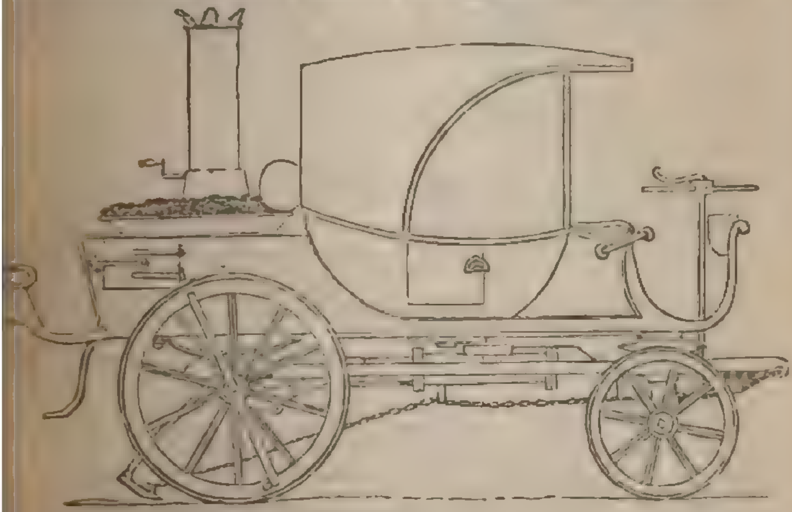


Goldsworthy Gurney's Steam Carriage.—First Patent 1825.

blocks *d*, and its ends are made fast to the other vibrating lever *f*; consequently, these two levers acquire reciprocating motions from the action of the piston rod. At the extremity of the crane's neck *g*, the two oscillating levers *h h* are suspended, and these being respectively attached by connecting rods *i i* to the levers *e* and *f*, move simultaneously with the last-mentioned levers as the piston of the engine works to and fro. The lower ends of the levers *h h* are attached

by joints to the horizontal rods *k l*, and these rods are connected to the sliding blocks which move the legs or crutches *m n*. The horizontal rods *k l*, and also the blocks which carry the legs, slide along in rebated grooves, formed in the under side of the perch *a*, which grooves are represented by dots, and a portion of the side of the perch is removed in the figure, to show one of the blocks *o* with its rollers within. The block *o* has small vertical wheels, or anti-friction rollers, by which it is enabled to run freely along the rebate or ledge of the groove; it has also small horizontal rollers, to prevent the block from rubbing against the sides of the groove. In the under side of each of the blocks a pin *p* is fixed, which is intended to pass through the top of the legs *m* or *n*, and a small helical spring is placed upon the pin, and secured by a screw nut, for the purpose of keeping up the top of the leg against the under side of the perch, but yet affording it some degree of play. By the action of the steam engine, and the other mechanism connected thereto, the blocks *o* are made to slide reciprocally to and fro along the grooves of the perch, in the manner above described; and supposing one of the legs or crutches to be brought into the situation of *m*, the foot will take hold of the ground, and remain stationary, while the force of the machinery pressing against it will cause the carriage to slide forward, and the leg *m* to assume the situation of *n*, while *n* will be advanced into the situation of *m*; and *vice versâ*. Thus, by the reciprocating movements of the machinery, the carriage will be progressively impelled forward by the crutches or legs. In order to turn the carriage round corners or angles in the road, the axle of the hinder wheels is made to move round horizontally, upon a central pin, by means of a strap or other contrivance applied at *q*. By this strap and a suitable handle or lever, the conductor guides the course of the carriage in a straight or curved direction.

No pretensions are made by Mr. Gurney in his specification of having invented any part of the machinery described therein but the "guide rollers" to the crutches, as the crutches themselves were suggested by previous patentees;

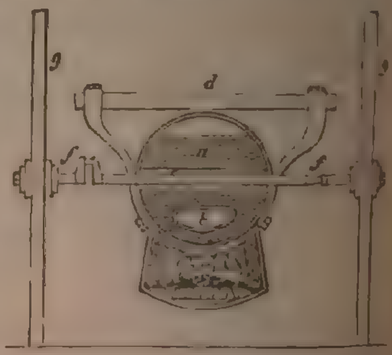


GURNEY.—1831.

and it will be seen that these crutches and rollers were abandoned as useless by Mr. Gurney himself. Were we to describe minutely the numerous contrivances and alterations made by the patentee and his assistant, it would occupy as much space as the whole of this article, and be at the same time a very uninteresting and profitless history of errors and failures, which few men having a knowledge of steam and machinery would have committed.

The preceding carriage represents one of the latest productions of Mr. Gurney, who built three upon the same model for Sir Charles Dance, which ran regularly from Cheltenham to Gloucester during a period of three or four months. These carriages were employed as *drags*, to draw after them the passengers contained in a light carriage of the omnibus kind. Only one of the drags was, we believe, in use at a time, the others being kept in dock to supply a fresh one, whenever repairs became necessary to the one in use.

An arrangement for a locomotive carriage was patented in December, 1826, by Mr. Frederick Andrews, of Stamford Rivers, in Essex; the peculiarities in which consist, first, in employing a single steering wheel in front of the carriage, the axis of which revolves in two lateral bars of a framing that connects it to the axletree of the four wheels, and thereby turns the latter with it. To give effect to this steering wheel, the framing is designed to carry luggage, or other sufficiently heavy articles. Another arrangement of the inventor's consisted in employing a pair of engines working upon pivots or trunnions, so that by their vibrations the piston rods might be directly connected to the throws of the crank, and adapt their inclinations to the varied motion of the latter. The other arrangements will be easiest understood by reference to the annexed cut. *a* shows a vertical section of a cylindrical boiler; *c* is the furnace, the heated matters from which pass longitudinally under the boiler, and then return to the front through a central flue *b*, before it enters the chimney, not shown. Transversely through the centre of the boiler there is a tubular passage, open at each end, through which the axis of the wheels *g g* passes, sufficient space being made in that tube for the cranked portions *f f* of the axis also to pass through. The piston rods being connected to the throws of the crank, it of course causes them to revolve, and with them the wheels by which the carriage is propelled. The boiler is suspended by stout iron arms to a frame above, which forms a part of the general frame, and is supported upon springs; the furnace *c* is suspended to the boiler by straps, the sides of which are lined by a series of horizontal tubes, in connexion with the boiler, which serve the double purpose of intercepting lateral radiation, and of assisting in the generation of vapour.



Andrews's Steam Carriage.—Patent 1826

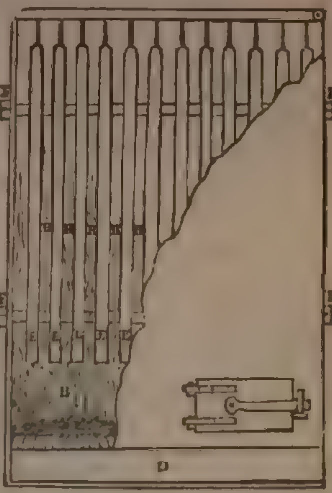
Mr. Neville, of Shad Thames, London, took out a patent for steam locomotion in 1827, the chief object of which appears from the specification to have been to prevent the wheels of a locomotive carriage from slipping round. To effect this he proposed the application of points and plates to the periphery of the wheels. But as these contrivances were worse than useless, and the arrangements of the steam carriage contained nothing worthy of particular remark, we abstain from all detail.

Amongst the singular propositions for producing a locomotive action, was that invented by Mr. T. S. Holland, for which he took out a patent, in 1827. The invention consists in the application of an arrangement of levers, similar to that commonly known by the name of *lazy-tongs*, for the purpose of propelling carriages. The objects appear to be, to derive from the reciprocating motion of a short lever a considerable degree of speed, and to obtain an abutment, against which the propellers should act horizontally, in the direction of the motion of the carriage, instead of obliquely to that motion, as is the case

arriages are impelled by levers striking the earth. The drawings to the specification seem designed rather to explain the principle than ent what the patentee would deem an eligible form of its application: such an application is not likely to be ever considered eligible, on of the excessive waste of power from friction, we must content our- by referring the reader who may require more information on the to the inrolled document.

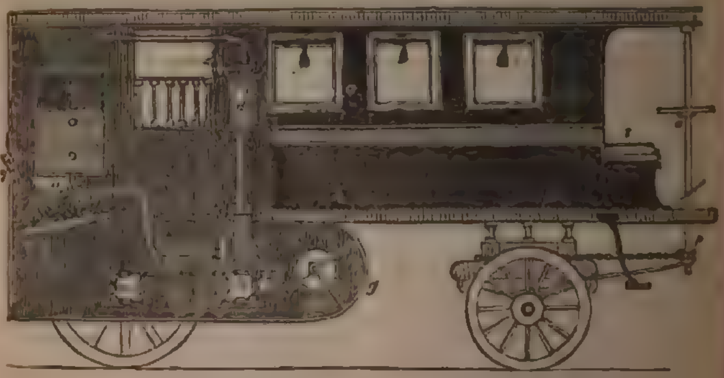
days after the before mentioned grant, Dr. Harland, of Scarborough, the great seal for supposed improvements, which we doubt not proved lous; we shall therefore give but a brief sketch of the nature of them. aeton-like frame at the back of the carriage, are situated the boiler ed of two double cylinders), the fire-grate, ash-pit, chimney steam water reservoir, and working cylinder, &c. After the steam has passed the latter, it is conducted to a series of tubes, underneath, and in front arriage, for the purpose of condensation by the cooling influence of the ere. The fruitlessness of such attempts, which has been long before de- (owing to the slow conductibility of the air), together with the defects uction, renders it needless to enter into details.

Walter Hancock, in the year ook out a patent for a high boiler, for locomotive pur- In the annexed engraving is ted an elevation of the first tion of this boiler, with a part sing removed to show the structure. At B is the fire- D the stoke-hole; E E are a flat parallel chambers to hold r, made of the toughest sheet d placed side by side, at a distance apart for the flames ted air to pass up between shown at H H. Each of vessels extends across the chamber, so as to fill its whole vertical plane; and they are ected at the bottom, for keep- water in each at a uniform d at the top of each of the there is a steam-pipe that to another larger steam-pipe, to them all, and by which the are supplied. To keep the



water chambers E E at uniform distances apart, and confer, at the e, adequate strength to them, a series of vertical bars or fillets are tween each pair. Therefore, instead of the flames ascending between of plates in one unbroken sheet, it is subdivided, and made to pass number of rectangular channels, representing in their outline so many ubes. This combination of water chambers and alternate flues is bound by a system of very massive bolts externally, proved to be capable of a vastly greater pressure than the boiler is ever subjected to; and it tionably a great merit in this boiler, that the thinness of metal, and t weakness of the individual water chambers, constitutes each, in safety valve. An increased efficiency was afterwards obtained by ng" the plates; by pressing them between dies, so as to cause a series herical bosses, of nearly the shape and size of watch-glasses, to be all over their external surfaces; so that when the chambers are brought the tops of these come into contact, and thus a series of spaces are etween them, through which the heated gases ascend in a devious pinging successively upon each boss in their passage.

Mr. Hancock being satisfied that he had obtained in this boiler the requisite means of generating adequate power, turned his attention to the various arrangements of the carriage and propelling machinery. His first carriage was constructed upon three wheels, and the power was applied through the medium of two vibrating engines fixed upon the crank axle of the fore wheel. Finding this mode of applying the power direct to the crank axle practically ineligible, Mr. Hancock next placed the engine quite behind; new difficulties occurred in this arrangement, and a third carriage was built, and called in reference to the infancy of the undertaking, the "Infant."



HANCOCK'S STEAM CARRIAGE "INFANT."—1830.

At *a* is the fire-place, *b* the ash-pit, and *g* a blower. The fire place and ash-pit are made close, that is, admitting only of a current upwards. The fireman, who sits on a small seat behind the boiler, views the state of the fire through eyeholes, and supplies coke through a feeding hopper at *q*. Steam is supplied to the engines *d*, of which there are two, through a pipe *r*, regulated by a valve at *s*. At *t* is the parallel motion, converted into rotary by the connecting rod *v*, actuating a crank *e* in the axis of a pair of chain wheels. There are two other chain wheels on the axis of the running wheels; and two endless chains communicate the force and motion to the latter. The engines are fixed securely upon springs, also the cranks and pumps. Several subordinate contrivances we have not room to describe. This carriage was the first that ran on a common road for hire, which it did for several weeks together, between Stratford and London. Mr. Hancock built several carriages subsequently to the INFANT, which were at different periods on the public roads for hire, for months together. But they did not meet with that patronage that was expected.

The next locomotionist who received the great seal, was Mr. Nathan Gough, of Salford, some of whose arrangements possess originality, and are not destitute of merit. The form of the vehicle for the reception of the passengers is similar to that of an ordinary stage coach, having a great boot behind, and another in front, for containing the principal parts of the propelling machinery. Under the back seat of the carriage, extending its entire length, and about a foot more in depth, is an iron case, which encloses four vibrating engines on trunnions, working as many throws of a crank, radiating from their common axis at uniform angles of 90° with respect to each other. This cranked axis is lengthened out beyond the range of the engines about one foot on each side, whereon are placed two pitch chain wheels; around these pass two endless

...ains, which also go round two similar chain wheels, fixed to the run-...s of the carriage. The chain wheels are made so as to run loose ... cranked shaft, and are fixable thereto at pleasure, by means of ...oxes, placed under the control of the guide or steersman, so that he ... them into or out of gear according to circumstances, by simple pres-... his feet upon two "foot levers," one for each foot, so that by pressing ...ot, the chain wheels are locked to the axis, and, by pressure on the ...eels are unlocked by sliding back upon the axis, when they run ...t is, the rotation of the axis by the force of the engines does not ...tion to it. By another movement the chain wheels are brought into ...th contiguous gear for producing a slow motion, as in ascending a ...hen the work becomes lighter, the steersman, by his foot, shifts back ... wheels to the quick motion, or he may entirely disengage the con-...rts, and thereby stop the progress of the carriage.

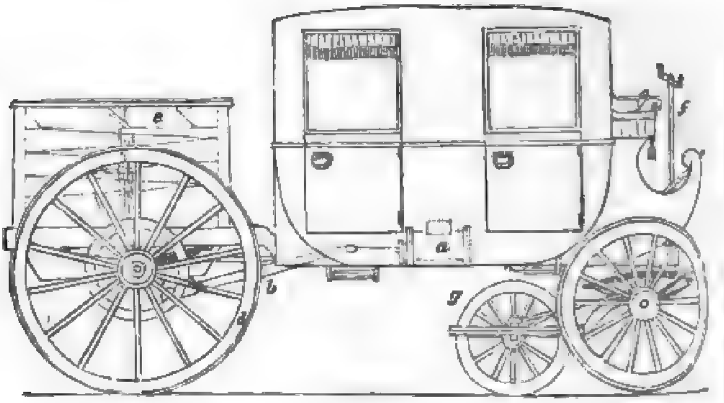
...nt wheels of the carriage have separate independent axles, which turn ...y upon a perpendicular column affixed to the fore framing. To guide ...ge, the steersman sitting in front turns a vertical spindle, the lower ... of which carries two arms, that, by connecting rods attached to the ...frames of the two fore wheels, places them in the oblique direction ...ccording to the curve of the road. Each of the fore wheels being ...to turn on its own centre, renders the action of guiding exceedingly ...

...ler is situated quite at the back of the carriage, and it is judiciously ... a large cylinder, with a series of small tubes passing through it for ... flues. The lower part of the boiler is divided by perpendicular par-... prevent the water from leaving it uncovered during the ascent or ... hills or inclined planes, or from the effects of other disturbing causes. ...te the admission of the steam to the cylinders, and its exit therefrom, ... of three-way cock is employed; this is placed under the control of the ... that he may diminish or increase the quantity, and by a further turn, ... be desired to stop the carriage suddenly, allow the steam to blow off. ... from the last-mentioned cock next passes through a "distributing ...d then enters each cylinder through passages on its trunnions, regu-...cock fixed on each, which admits the vapour alternately on each side ...tons, as the cylinders vibrate on their centres. The steam which is ... of the working cylinders by the back stroke of the pistons, is con-...rough a pipe into a chamber, which the patentee calls the heating ...herein is also received the steam that blows off from the safety valve. ... vessel connected with the boiler, containing a float, by means of ... amount of water forced into the boiler is regulated. This pump is ... a lever, acted upon by a cam, that revolves upon the crank shaft. ... for the supply of the boiler is forced by the pump through a long ...be in the heating chest, by which the temperature of the fluid becomes ...bly heated before it enters the boiler. There is also a float in the boiler ... with the water way of the pump, which, as the water rises in the ...ses the supply valve, so that if the pump continues in action, no more ... be injected, but it will be returned through the cold water pipe. ... two water tanks, one on each side of the carriage, next to the hind ...ing wheels, and between these tanks is the coal-hole.

... year 1830, Messrs. Summers and Ogle obtained a patent for a ...riage. The principal feature in it was the steam generating ..., which is already described in the article BOILER. The arrange-... communicating the force of the steam to the carriage wheels, consisted ... the axis of the latter into a three-throw crank; each throw being ..., or at 120° apart from each other, for converting the rectilineal ...into rotary with the greatest uniformity of force; which motion was ...om three cylinders, vibrating on trunnions. Very flattering reports ...ration of this carriage were published, and others of a contrary ..., but private interest probably influenced both sides of the question.

... same year as the last mentioned invention, Messrs. Boase and Rowe

brought out a patent locomotive carriage, the annexed illustration of which will assist in the comprehension of it. The engines were situated in a case underneath the body of the carriage, as shown at *a*, and by the piston rod and



RAWE AND BOASE'S STEAM CARRIAGE.—PATENT 1830.

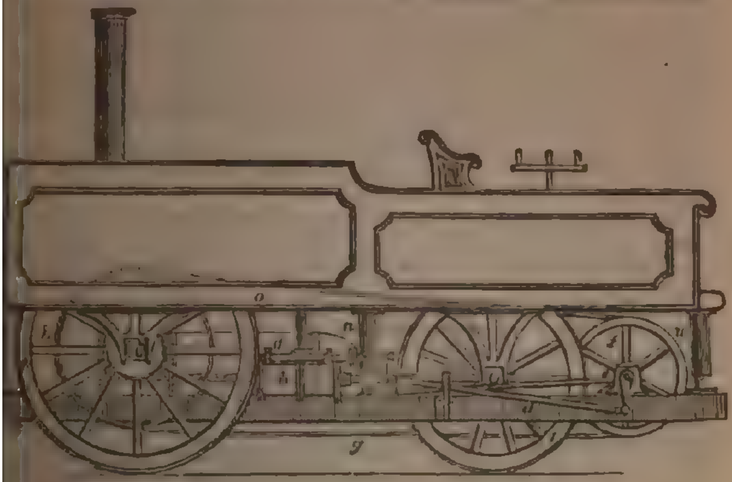
connecting rod *b*, gave motion to the cranked axles of the running wheels *d* of the carriage. The boiler *e* was bolted to a strong framing, and was contained in a double case, the space between being packed with non-conducting substances. The boiler consisted of 12 tubes of small diameter, each bent into a spiral curve of three convolutions, of the same pitch and height, but of uniformly varying diameters; so that when each successive spiral was placed side by side (the smaller inside the next larger in diameter) they formed by their concentric junction a continuous spiral sheet of tubes; with a steam chamber in the centre. Underneath the whole was the furnace of the entire area of the boiler, that is, about 4 feet 6 inches in diameter.

Messrs. W. G. and R. Heaton, of Birmingham, built several steam carriages, under a patent-right dated 1830; but their mechanism was too complicated to be understood without the aid of drawings, which our space will not admit: and as the patentees had the remarkable candour to acknowledge publicly the failure of their scheme, a very brief notice is all that we are called upon to give: and for this further reason; because the Messrs. Heaton did not pretend to have invented any of the separate or distinct parts of their machine, but merely the general combination of the entire structure, which is a claim of scarcely any value to the most successful inventor; the identical combination being so easily destroyed. Their boiler was of the tubular kind, with a cylindrical arrangement, like James's; their steering apparatus was also like that of the same person; their engines after some other locomotionist, and so on throughout most of the parts. In the annexed condensed extract from the specification, descriptive of their mode of applying the steam power to the vehicle, they have availed themselves of the plans of the renowned progenitor of steam coaches, Trevithick.

Motion is communicated to the driving wheels by a double set of spur wheel gear, arranged to give different powers or velocities, by having both a large and a small wheel fixed on the driving as well as the driven axis. By shifting the large wheel on the driving axis into gear with the small wheel on the driven axis, speed is obtained; and by shifting their relative position till the small wheel on the driving axis comes into gear with the large wheel on the driven axis, power is obtained at the expense of speed. These two axes are kept at the same distance from each other by means of connecting rods,

-ithstanding the relative position may be changed by the motion of the -riage on rough roads.

-essrs. Napier describe their improvements in steam carriages to consist :— -rst, in communicating the power of the engines for propelling the carriage -e wheels, by means of a belt, strap, or band, which works upon two pulleys, -one fixed upon a shaft connected with the engine or engines, the other fixed -, or connected with, the axle or wheels of the carriage. This will be -er understood by reference to the annexed cut. *a* is a horizontal steam -r, with an hemispherical end ; at *b* are the two cylinders of the engines -sing horizontally, and fastened upon the boilers ; *c c* is the framing of -ines, which is also fastened to the boilers and engine cylinders ; *d* connecting - of engine ; *e* the crank shaft of engines, upon which is fixed the pulley or -m *f*, from which pulley the strap *g* communicates the power of the engine -he pulley or drum *h*, which in the present case is fixed on the middle of the



Napier's Steam Carriage—Patent 1831.

-l axle, *i*, *k k* the hind wheels of carriage ; *l* fore wheel of carriage, which - on a circular plate for the purpose of guiding the carriage on the common -. The boilers and engines being firmly fastened together, thus form one -e piece, which is suspended by springs *n n n*, from a frame work *o o*, resting - the wheel axles of the carriage, and having no connexion with the said -age or frame-work, but by belts, straps, or bands, which are designed to - it from jolts and concussions.

- patent, for a variety of improvements in locomotion, was granted to Mr. -H. Palmer in 1831 ; but the specification is so extensive and elaborate, that -can do no more than state his claims to invention, and refer the reader to -Inrolment Offices for the details. These are as follow :—

-irst, The self-regulating blast apparatus, by which the quantity of fuel to be -ed in a given time is governed, in order to insure the generation of a volume -team, suited precisely to all the variable speeds and powers of the engine.

-econdly, The steam calorific self-adjusting apparatus, which acts in conjunc- - with the blast regulator, and is so contrived as to lift the weight from the - of the safety valve, and permit the steam to escape from the boiler should -aforesaid apparatus fail of instantly checking its evolution.

-hirdly, The self-acting safety apparatus, by which the security of the boiler -sured, should the apparatus for supplying it with water fail in its effect, so

that in the event of the water in the boiler being reduced below a determined level, the process of combustion will be instantly suspended, and the boiler protected from injury.

Fourthly, Making the products of combustion evolved from the furnace escape into the atmosphere below the level of the furnace bars, which will more effectually prevent the admission of atmospheric air into the furnace, excepting that portion which the blast and calorific regulating apparatus permits the blowers to project upon the fuel undergoing combustion.

Fifthly, The pipes leading from the opposite ends of the horizontal part of the boiler are designed to convey the water (which must be distilled) most remote from the direct action of the furnace, to replace that portion which may be carried to the upper part of the boiler by the great volume of steam generated between the two concentric cylinders.

Sixthly, To insure a length of stroke in high pressure engines, and that without increasing the diameter of the piston rods beyond that which is required to withstand the alternate tug and thrust; and without resorting to the very objectionable short stroke and piston rod of so large a diameter.

Seventhly, The slide valves, with their various modifications, requiring neither casings nor stuffing-boxes, the patentee claims as perfectly novel; the action of these being seen, admit of mathematical adjustment, and enables the engineer instantly to reverse or stop the engine at pleasure.

Eighthly, For a modification of the crank and beam intended to supersede the use of a beam of the usual weight and dimensions, parallel motion, cross heads, and costly fittings and bearings connected therewith. This mode of converting the reciprocating into the rotative motion, the patentee says, "accomplishes the grand desideratum of making one cylinder produce a more regular and equalized motion than can be accomplished by two cylinders when used to give motion to locomotive engines or paddle wheels."

Ninthly, The condensation by which highly elastic steam of any temperature may be converted into water, without the application of injection, or by the extension of surface by making the cubic contents of the condensing chamber equal to the number of cubic inches of steam discharged.

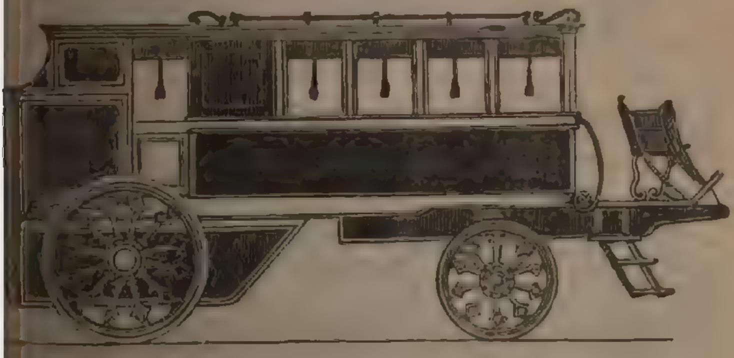
We have now to *notice* the labours of Mr. Joseph Gibbs, late of the Kent Road, and Mr. Augustus Applegath, of Crayford in Kent, who had a joint patent, dated 29th March, 1833, for "certain improvements in steam-carriages." To give an intelligible description of the many contrivances contained in this elaborate specification, our space is inadequate; we must therefore be content with giving an idea of the nature of the subjects, and refer the inquiring reader to the enrolled parchments.

The first described improvement relates to the general arrangement of a steam-carriage. The boiler is of a novel description, and consists of a series of double cones arranged one over the other, the external angles or spaces between which are receptacles for water, which is circumscribed externally by a cylindrical casing. The fire is in the centre of the series of cones, and operates upon their extensive surfaces; and the flue is so arranged as to repeat the heating operation by a descending current. There is also a curious combination of shafts, wheels, couplers and springs for varying the speed, &c.

The locomotive carriage, contrived by Dr. W. H. Church, being patented in 1832, next comes under our observation. The principal novelties claimed by him, consist; first, in making the frame of the carriage of a combination of wood of small scantling combined with angle iron, to give it the requisite strength. A framework of this kind, well trussed and braced, incloses a space between the hind and fore-body of the carriage, and of the same height as the latter, and is to contain the engines, boiler, &c. The boiler consists of a series of vertical tubes, into each of which is introduced a pipe that passes through, and is secured at the bottom of the boiler tube. The interior pipes constitute the flues, each of which, after passing through the boiler tube, is bent syphon-wise, and passed down till it reaches as low or lower than the bottom of the fire-place, whence it passes off into a general flue in communication with an exhausting apparatus. Some other complications of tubes form a part of the arrangement,

which our limits forbid us to describe. Two fans are employed, one to blow in air, and the other to draw it out; they are worked as usual, by straps from the crank shaft. The wheels of the carriage are constructed with the view of rendering them to a certain degree elastic, in two different ways: first, the felloes are made of several successive layers of broad wooden hoops, and these are covered with a thin iron tire, having lateral straps to bind the hoops together; second, these binding-straps are connected by hinge joints, to a kind of flat steel springs, somewhat curved, which form the spokes of the wheels. These spring spokes are intended to obviate the necessity, in a great measure, of the ordinary springs, and the elasticity of the periphery is designed that the yielding of the circle shall prevent the wheel from turning without propelling! Dr. Church, however, proposes, in addition to spring felloes, spring spokes, and the ordinary springs, to employ *air* springs, and for that purpose provides two or more cylinders, made fast to the body of the carriage, in a vertical position, closed at top, and furnished with a piston, with packing similar to the cap-leather packing of the hydraulic press: this piston is kept covered with oil, to preserve it in good order, and a piston-rod connects it with the supporting frame of the carriage. Motion is communicated by two oscillating steam cylinders, which are suspended on the ends of the eduction and induction pipes over the crank shaft. The crank shaft and driving-wheel axle are connected together by means of chains passing about pitched pulleys; and there are two pairs of these pulleys, of different sizes with respect to each other, by which the power may be varied, by shifting the motion from one pair to the other, by means of clutch boxes.

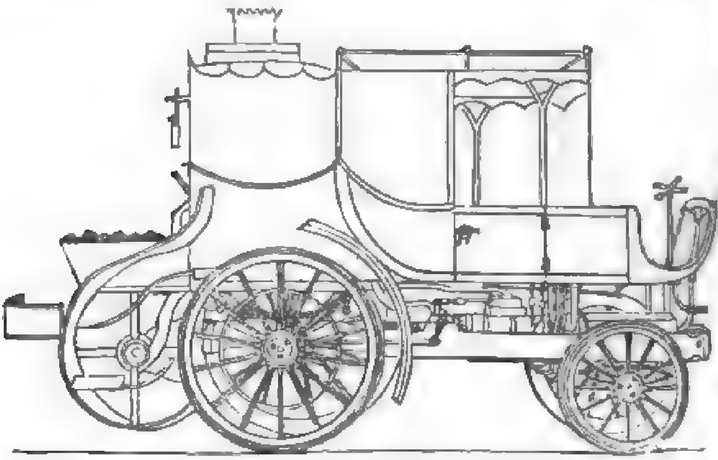
In October, 1832, Mr. Redmund, of the City Road, patented a boiler, especially designed for locomotive uses. It consists of a series of parallel vertical chambers with corrugated sides, for the purpose of extending the heating surface, and accelerating the production of steam in a compact apparatus. The principal difference between it and Mr. Hancock's, is in the circumstance of the corrugation. Mr. Redmund, shortly after the grant of his patent, constructed a steam carriage, which is represented in the subjoined cut. The wheels are



entirely metallic; the spokes are cast hollow or tubular, and of an ornamental design. The arrangement and position of the chief part of the propelling mechanism is the same as Hancock's. The guiding is effected by reins in a similar manner to those of horses, each rein operating separately through the medium of levers in turning the fore wheels of the carriage to the right or left; and to facilitate this motion, each wheel revolves on a distinct axle supported in a frame that turns horizontally upon a pivot, after the manner of Ackerman's patent of 1816.

A tubular boiler for locomotive purposes, was patented jointly by Mr. John Squire and Colonel Maceroni, on the 18th July, 1833. It consists of nine rows

of upright cylindrical tubes, each row containing nine tubes. In the middle of these the fire-place is situated; and to obtain the requisite space for it and the fuel under combustion, a portion of the interior ranges of tubes are proportionably shortened, as well as three of the front tubes, to form a fire-door. All the vertical tubes are connected by means of small horizontal tubes at the top and at the bottom; the upper being a steam communication, and the lower a water communication; but as they are all open to each other, and the application of the heat cannot be precisely uniform in every part, a circulation of the fluid necessarily ensues. The fire-bars are formed of hollow tubes, filled with water, and communicating with the vertical tubes. The steam is conducted from the latter tubes by means of small pipes entering the otherwise close tops of each, into a central recipient, from which the engine is supplied. The engines

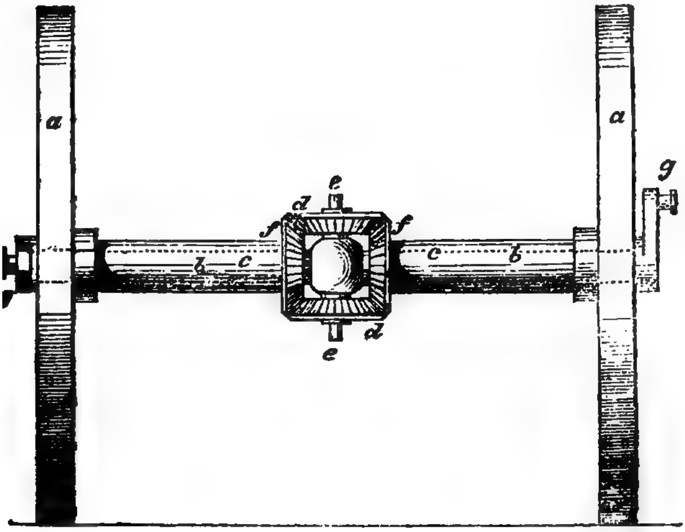


are placed horizontally underneath the carriage body; the boiler is at the back, and a blast is employed to excite the combustion of the fuel, the supply of which is regulated by an engine man, who has a seat at the back for attending to it. The passengers are placed in the open carriage body, and their seats are formed upon the tops of the water tanks. There are two working cylinders $7\frac{1}{2}$ inches diameter, and $15\frac{3}{4}$ inches length of stroke. The steam-ways are $2\frac{1}{4}$ and $2\frac{3}{4}$ inches diameter.

The last experimentalist in the department of common road locomotion whose labours we shall notice, is Mr. F. Hills, of Deptford. Mr. Hills devoted much time and went to great expense in his endeavours to construct a compact and efficient boiler, and to bring the weight and dimensions of the machinery within moderate and practical limits; and at length so fully mastered the practical difficulties of his task, that a company was formed for building and running carriages constructed according to his plan, and an act of incorporation was applied for; but failing to obtain the clause for limiting the responsibility of the shareholders to the proportion of their shares, and the railway mania beginning to manifest itself at the same time, the company was dissolved, and Mr. Hills retired from the field. In the course of his experiments, Mr. Hills constructed several carriages with which he performed numerous journeys on the public roads; selecting those which, from the peculiar difficulties they presented, were most likely to point out every variety of provision that required to be made, or circumstances to be guarded against. The Windsor, Brighton, Hastings, and similar roads were traversed by him with uniform success; and

nongst other performances, we may state, that the journey to Hastings (64 iles) and back was performed in one day, each journey being accomplished one half the time occupied by the coaches. One of the improvements mprehended in the last of Mr. Hills' patents, from its originality, extreme genuity, and the perfect manner in which it attains the object in view, calls r particular notice. One of the difficulties attending the construction of comotive carriages, is the connexion of the driving wheels with the machinery, as to obtain the full adhesion of the wheels, and at the same time to allow cility in turning sharp curves. Mr. James, as we have already noticed in one f his earliest attempts, fixed each of the driving wheels upon a short and parate axle, and applied two steam cylinders (at right angles to each other) drive each wheel, but this added greatly to the complexity of the apparatus; nother inventor employed only three wheels in his carriage, and applied the ower to a single wheel, which ran in advance of and between the tracks of e other two. The plan, however, most commonly resorted to, was to fix one heel to the axle and to connect the other to the axle by a sliding clutch; but it was impossible for the steersman to lock and unlock the wheels at every dden turn the carriage might be required to make, and great friction would ve been created by the *skidding* of the wheels had both been fixed, the actice was to drive generally with only one wheel fixed, and to lock the other ascending hills, where the whole amount of adhesion might be required. By r. Hills' arrangement, the objections to which all previous plans were liable completely obviated; the adhesion of both wheels is constantly exerted to pel the carriage, and without the slightest attention on the part of the driver, power exerted by the engines is exactly proportioned to the space each eel passes through in describing the sharpest curves.

The engraving represents Mr. Hills' arrangement for connecting the driving eels with the axle and the engines. *a a* are the driving wheels, which are



ed upon two tubes or boxes; *b b* through which the axle or driving shaft *c* ses, as shewn by the dotted lines, the tubes being loose upon the shaft; *d d* two bevelled wheels which turn upon two pins *e e*, fixed upon the centre of shaft, and which work into two similar wheels *f f*, fixed upon the tubes *b b*,

the four wheels being all geared together; *g g* are the cranks fixed upon the ends of the shaft at right angles to each other, and to which the connecting rods are attached. Upon examining the figure it will be seen, that so long as the wheels continue to run in a straight line, the tubes *b b* do not revolve upon the axle, but turn round with it, and carry round the wheels as if they were fixed to the axle; but upon any deviation from a straight line, the wheels, at the same time that they advance with the axle, revolve more or less (according to the sharpness of the curve) upon the axle in contrary directions, the outer wheel having a forward, and the inner wheel having a backward movement; so that the actual advance of the outer wheel exceeds that of the inner wheel as much as the length of the outside curve exceeds that of the inside curve, and thus no skidding takes place.

STEAM ENGINE.—A machine wrought by the force obtained from the expansion and contraction of the steam of boiling water, and employed as a first moving power to other machines.

Before proceeding to describe the construction and arrangement of the engine it will be proper to give a brief exposition of the principles upon which the action of it depends.

The mechanical power exerted is the effect of the physical changes produced in water, by great and sudden alterations of its temperature. By an addition of heat, it is changed from a dense incompressible liquid, into an invisible, highly elastic fluid, the bulk of which exceeds, by many hundred times, that of the water of which it is formed. This change of state, however, is not permanent; an abstraction of the heat from the steam reducing it again to water. These changes, either separately or combined, are the cause of motion in every modification of the steam engine.

The effects of heat upon water are of two kinds; it first raises the temperature until it reaches a certain point, when it becomes stationary, and the continued action of heat then converts the water into steam; the temperature of which remains the same as that of the water from which it is formed. But although the *intensity* of the heat of steam, as indicated by the thermometer, is the same as that of the boiling water; the *quantity* of heat in a given weight of steam, exceeds considerably the quantity of heat in the same weight of boiling water. This heat is that which is necessary to maintain the water in the state of vapour; and if any portion of it be withdrawn, a corresponding portion of steam is rendered liquid. From the heat not being apparent by the thermometer, it is termed *latent* heat. The quantity of latent heat combined with steam, is variously given by different authors; the best experiments appear to fix it at about 1000, or about $5\frac{1}{3}$ times the heat of boiling water; it being found that 1lb of water converted into steam, will raise $5\frac{1}{2}$lbs of water from 32° to 212° Fahr. From various experiments it likewise appears, that the latent heat is nearly the same, whatever be its temperature as indicated by the thermometer.

The temperature at which water boils or is converted into steam depends upon the pressure upon the surface of the water. Exposed simply to the common pressure of the atmosphere, water boils at 212° Fahr.; but upon the tops of lofty mountains, where the mercury in the barometer indicates a much smaller pressure, the temperature of the boiling point is proportionately lower; and on the other hand, if water be confined in a vessel from which there is no escape for the steam until it attains a certain pressure, the temperature of the boiling point will be proportionately raised.

In like manner the pressure of the steam varies with and is proportional to the temperature at which it is formed. The determination of the elastic force of steam of different degrees of temperature, is of the greatest importance to the practical engineer, and the subject has consequently undergone much investigation. The experiments of Watt, Dalton, Robins, Southern, Ure, Arsberger and Philip Taylor have all been of great service in determining this question.

The two tables given for greater perspicuity in the next page—the first being the result of a series of experiments made by Dr. Dalton, the second supplied by the Royal Academy of France, in their report upon the comparative degree of safety between high and low pressure engines—are inserted as being not only

especially

TABLE

the Expansive Force of Steam when contained in a close Vessel, taken at every 0° of Temperature from 212° Fahrenheit, (the Boiling Point,) up to 320°.

Temp. Fahr.	Pressure of Steam, or the Force which it will exert to enter into a vacuous Space.			Pressure of the Steam against the Atmosphere, when the Barometer is at 30 Inches, or the Force it will exert to escape from the closed Vessel into the open Air.		
	Column of Mercury.	Column of Water.	Pressure per Square Inch.	Column of Mercury.	Column of Water.	Pressure per Square Inch.
	Inches.	*Ft. In.*	*Lbs. Oz.*	*Inches.*	*Ft. In.*	*Lbs. Oz.*
212	30.	33 11	14 11	The Steam	equal to the	atmosph.
220	35.	39 6	17 1	5.	5 7	2 7
230	41.75	47 2	20 7	11.75	13 4	5 13
240	49.67	56 1	24 4	19.67	22 3	9 10
250	58.21	65 9	28 8	28.21	31 11	13 14
260	67.73	76 6	33 2	37.73	42 8	18 8
270	77.85	87 11	38 1	47.85	54 1	23 7
280	88.75	100 3	43 7	58.75	66 5	28 13
290	100.12	113 1	49 0	70.12	79 3	34 6
300	111.81	126 4	54 12	81.81	92 6	40 2
310	123.53	139 6	60 8	93.53	105 8	45 14
320	135.	152 6	66 1	105.	116 5	51 7

Elasticity in Atmosphere.	Height of Mercury in Inches.	Temperature of Fahrenheit.	Pressure per Square Inch, in lbs. Avoirdupois.
1	29.92	212.	14.61
1½	44.88	234.	21.92
2	59.84	251.6	29.23
3	89.76	275.	43.84
4	119.69	293.4	58.46
5	149.61	309.2	73.07
6	179.53	322.7	81.69
7	209.45	334.4	102.30
8	239.37	343.4	116.92

essential to the practical engineer, but of the greatest interest to the scientific engineer. They differ in no very material point from other calculations that have been made, and are quite near enough to be adopted as a standard for guidance in mechanical operations.

The volume of steam into which a given quantity of water expands, depends upon the pressure of the steam. At the temperature of 212°, one volume of water furnishes nearly 1,800 volumes of steam, of a pressure equal to that of the atmospheric, or about 15lbs on the square inch. With an increased pressure its bulk is diminished, but in what ratio is not quite settled. From the experiments of Mr. Southern and also those of MM. Clements and Desorme, all conducted with great care, the same law appears to hold good with respect to steam, as with other æriform fluids, that the density is directly as the pressure, or the volume inversely as the pressure. Thus, if at the pressure of the atmosphere or 15lbs per square inch 1 volume of water will furnish 1,800 volumes of steam; at the pressure of 2 atmospheres or 30lbs, it will give 900 volumes; at 4 atmospheres 450 volumes, &c. and this is the theory most generally adopted.

The motion of steam engines is derived from the following causes, namely:—

First, From the direct pressure of steam upon the piston. *Second*, From the condensation of steam on one side of a piston, and by the vacuum thus effected, obtaining the pressure of the atmosphere on the other side. *Third*, From the combined action of the pressure of steam on one side of a piston, and of a vacuum on the other side effected by condensation. To these may be added a *fourth*, which, for want of a more appropriate term, has been called the "reaction" of steam. The theory of the action in each case we will now briefly explain.

It has already been observed that water when converted into steam is increased in its bulk about 1800 times, at atmospheric pressure. It follows that a cubic inch of water will furnish a cubic foot of steam. Let us suppose a cylinder whose area is equal to one square foot, to contain a cubic inch of water; on the surface of which rests a steam tight piston, but which is free to move without friction, and that the weight of the piston is counterbalanced by a weight suspended from a line running over a pulley. If heat be now applied to the bottom of the cylinder, and the water be thereby converted into steam, the piston will be raised one foot high in the cylinder. In this case, however, no mechanical power is obtained, as the steam has merely overcome the pressure of the atmosphere. But let us suppose that in addition to the pressure of the atmosphere upon the piston, a load equal to 15lbs upon each square inch of its area, be placed upon it; the pressure of the steam will in this case be doubled, and will consequently raise the piston six inches in the cylinder; and the mechanical effect will be, 144 times 15lbs raised through the space of 6 inches. If the load upon the piston be increased to 30lbs, making with the pressure of the atmosphere 45lbs, the pressure of the steam will be trebled, the piston will be raised 4 inches in the cylinder, and the effect will be 144×15 through the space of 4 inches, exceeding the former effect in the ratio of 120 to 90: had the load been increased to 45lbs, exclusive of the atmosphere, the piston would have been raised through 3 inches, and the effects would have been as 135 to 90.

The cause of this increase of mechanical effect, by an increased pressure of steam, is, that in each instance, in addition to the mechanical load to be moved, there is the pressure of the atmosphere to be overcome, which in the first case amounted to one half the whole load, but in the last case to only one fourth of the whole load; the greater the pressure therefore of the steam, the greater the mechanical effect, or rather the smaller the loss of effect. But considerations of safety, and other circumstances, prevent this principle from being carried to a great extent in practice.

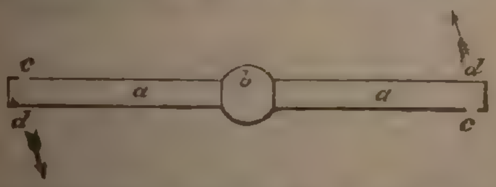
To illustrate the principle upon which the condensation of steam tends to produce a mechanical power; let us suppose that in the before described cylinder, the cubic inch of water has formed a cubic foot of steam, the pressure which just balances the pressure of the atmosphere upon the piston, which w[illegible] then be raised one foot high in the cylinder; if by any means the steam [illegible] suddenly condensed and reduced to one cubic inch of water, a vacuum will be[illegible]

formed beneath the piston, and the pressure of the atmosphere upon its surface, being no longer balanced by that of the steam beneath, will carry the piston to the bottom of the cylinder, with a force of 15lbs upon each square inch of its surface, or 2,160lbs in the whole. And if a weight of 2,160lbs be supposed to be attached to the line to which the counterbalance is hung, it will, by the descent of the piston in the cylinder, be raised one foot high; the mechanical effect therefore in this case is 2,160lbs raised 1 foot high. The above may be taken as an illustration of the principle of the atmospheric engine, as it is termed, which is the first form of the steam engine, in which the force of the steam was transmitted through a piston.

As respects the third mentioned cause of motion in steam engines, viz. the force produced by its pressure, combined with that resulting from its condensation; —the pressure of the steam is substituted for the pressure of the atmosphere, to impel the piston into the vacuum formed within the cylinder by the condensation of the steam. In this case the reader must suppose the cylinder before described to be fitted with a steam-tight cover, through a hole in which a rod attached to the piston works steam-tight, and that upon this rod is placed the load to be raised. If a vacuum be formed above the piston, and the cubic inch of water below the piston be converted into steam, the piston will be raised through a space which will be inversely as the amount of the load; thus, if the load be equal to 15lbs upon the square inch, it will be raised 1 foot high; if 30lbs per square inch, it will be raised only 6 inches; and so on, the product of the weight, multiplied by the space through which it is raised, being equal in all cases. Theoretically considered, therefore, the mechanical effect of a given quantity of water, converted into steam, is the same whatever the pressure of the steam may be; and is equal to that produced by the effect of the pressure of the atmosphere against a vacuum. But it is advantageous on many accounts, in practice, both to substitute the pressure of the steam for that of the atmosphere to impel the piston, and also to increase its elastic force beyond that of the atmosphere.

With respect to the fourth cause of motion in engines;—if steam be made to flow from a centre along a hollow arm, and to issue in a jet, near the extremity, in a direction at right angles to such arm, it will impart a rotary motion to the arm in an opposite direction to that of the jet. This motion is attributed by many to the "re-action" of the steam against the atmosphere, which is supposed to form the abutment to the steam. But this explanation is clearly incorrect, since engines constructed upon this principle of action will revolve in a close casing in which a vacuum it maintained.

Another, and, as it appears to us, the true theory, is that it results from a difference of pressure on the opposite side of the arms; which may be illustrated thus. Let *a a* in the diagram be supposed to represent two hollow arms, capable



of motion upon a hollow axis *b*, through which steam is admitted to the arms. If these arms have no outlet, the pressure of the steam will be the same in every part of their surface; and there being no issue of steam, no motion will take place. But if a small aperture be made in each arm at *c c*, the steam will rush out through them, and the pressure upon that side of the arms will be removed, whilst it will continue to be exerted upon the opposite points of the arms at *d d*, and the arms will therefore revolve in the direction of the arrows.

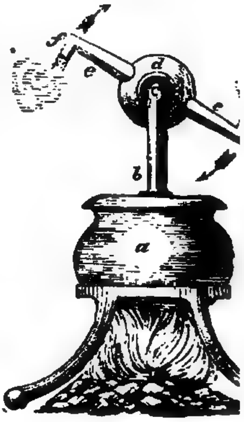
Having now explained the *theory* of the several causes of motion in the steam engine, we shall proceed to show the *practical* application of them, by the

description of a series of different engines, that are actuated by those
causes of motion; in doing which we shall introduce them in the order
discovery, our space not admitting of a historical detail of the successiv
by which the steam engine became the powerful and elaborate machine
it now exhibits.

The earliest contrivance of which we have any account, for making
the force of steam, is of unknown date. It is generally called Hero's
and though posterity is really not indebted to him for the invention, it
more beholden to him for the bequest of his description, than if he ha
the inventor and omitted to describe it.

Hero, *the elder*, was the son of a Greek, settled at Alexandria, who flo
about 130 years before the Christian era. In his work entitled *Spirit*
describes, among other ingenious machines, three modes in which steam
be employed as a mechanical power; to raise water by its elasticity, to
a weight by its expansive force, and to produce a rotary motion by its r
on the atmosphere. Although these contrivances only took the shape o
sophic toys, we have in them the undoubted germs of the vast power wh
present modification permits. Hero in the introduction to his work pr
to have made himself acquainted with the works of his predecessors an
temporaries; and, unwilling that they should perish or be overlooked, de
them, that they might be better and more generally understood; so th
probable the properties of expansion and contraction of steam were
long prior to the time in which he flourished.

The following is a brief description of the machine described by Hero for producing a rotary motion; the leading features of which have been the subject of several patents, taken out by uninformed persons; and there are several machines now in use on the same principle.



Hero's engine consisted of a hollow globe, having tubular arms, extending from it radially in opposite directions; and each of these tubes had a small opening on one of its sides near the extremity. The globe was suspended upon horizontal centres, one of which was hollow, and admitted steam, from a caldron situated beneath, with a fire under, into the hollow globe, which passing through the radiating tubular arms, issued laterally against the atmosphere, and produced a rotary motion, in the same manner as water produces that of Barker's mill.

At *a* is a caldron of water with a fire
underneath it. The caldron is closed at the top, except at the pipe *b*, wh
bent horizontally at *c*, and forms one of the two centres; the other is not v
as it is behind *b c*; *d* is the hollow globe, *e e* the hollow arms, bent at
right angles, for the emission of the steam in that direction.

The next proposal for the useful application of steam as a motive pov
to be found in a work by Solomon De Caus, an eminent French mathema
and engineer, published in 1615, entitled, "Les Raisons des Forces mouv
avec divers Desseins de Fontaines." The following description will e
the principle of his invention. *a* is a spherical vessel placed over a fir
furnished with two pipes *b e*. The pipe *e* is open at the top and reaches do
the bottom of the vessel *a*: the pipe *b* is furnished with a cock *d* and fun
the vessel being filled with water, and fire applied, steam is speedily gen
on the surface of the water, and having no other way to escape, (the cock *d*
shut,) presses on the surface and so forces the water up the tube
the air, causing a jet, which varies in proportion to the elasticity of the
within. It is upon the strength of the above invention, that De Caus h

many been regarded as the inventor of the steam engine; and although we cannot quite concur in this opinion, we certainly regard him as entitled to great credit, for although the arrangement was such as could not be beneficially applied in practice, we have here the distinct announcement of one of the principles upon which Savery, nearly a century afterwards, constructed his engine, which is the first effective one on record.

DE CAUS'S ENGINE, 1615.

In 1663 the Marquis of Worcester published a small tract entitled, "A Century of the Names and Scantlings of such Inventions as he had tried and perfected." In the 68th article of this Century he gives an inflated, boastful account of his "fire water-work," and in so obscure and contradictory a manner, that every commentator and writer on the steam engine, who has attempted to make out something reasonable from the pretended description, has been compelled to contrive and arrange what probably never entered into the imagination of the Marquis. Nevertheless, by many writers, implicit credit seems to be given to his assertions, and he is regarded as the inventor of the steam engine!

As far as the *principle* of his apparatus can be understood from his account, it appears to be the same as that which had been discovered, and much more clearly described, by De Caus fifty years before.

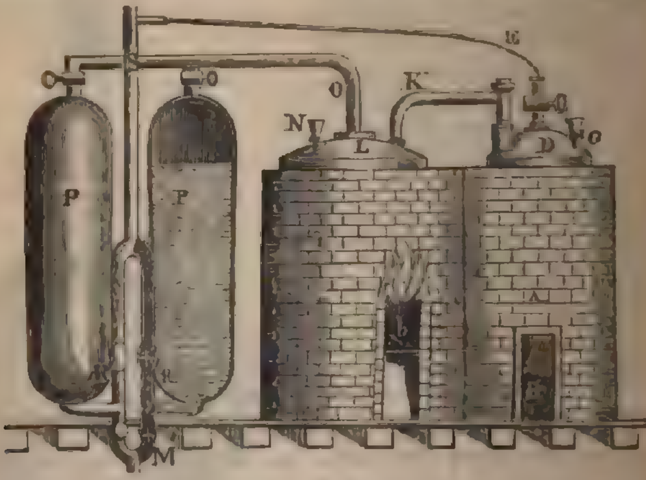
Although various expositions of the properties of steam, and suggestions for their application to move machinery, continued to be made from time to time by various persons, it is to Thomas Savery that we are indebted for the practical introduction of the steam engine as a moving power.

The following figure and description, nearly in Savery's own words, will illustrate the nature of his engine.

The first thing is, to fix the engine in a good double furnace, so contrived that the flame of your fire may circulate round and encompass your boilers, as you do coppers for brewing. Before you make any fire, unscrew G and N, being the two small *gauge pipes* and cocks belonging to the two boilers; and at the holes fill L, the large boiler, two-thirds full of water, and D, the small boiler, quite full. Then screw on the said pipes again, as fast and as tight as possible. Then light the fire at *b*, and when the water in L boils, open the cock of the first vessel P, (shown in section,) which makes all the steam rising from the water in L pass with irresistible force through O into P, pushing out all the air before it through the clack R; and when all is gone out, the bottom of the vessel P will be very hot, then shut the cock of the pipe of this vessel, and open the cock of the other vessel P, until that vessel has discharged its air through the clack R up the force-pipe S. In the mean time, a stream of cold water [supplied by a pipe connected with the discharging pipe, but not shown in the cut,] has been made to pass over the outside of the vessel P, *which, by condensing the steam within*, a vacuum or emptiness is created; so that the water from the well must and will necessarily rise up through the sucking-pipe, (cut off below M,) lifting up the clack M, and filling the vessel P.

The first vessel P being thus emptied of its air, open the cock again, and the force of steam from the boiler presses upon the surface of the water with an elastic quality like air, still increasing in elasticity or spring, till it counterpoises

or rather exceeds the weight of water ascending in the pipe S, out of which the contained water will be immediately discharged when once gotten to the top, which takes up some time to recover that power; but having once got it, and being in work, it is easy for one that never saw the engine, after half an hour's experience, to keep a constant stream running out the full bore of the pipe. On



Savery's Engine, 1699.

the outside of the vessel you may see how the water goes out, as well as if the vessel were transparent; for as far as the steam continues within the vessel, so far is the vessel dry without, and so very hot as scarcely to endure the least touch of the hand. But as far as the water is, the said vessel will be cold and wet where any water has fallen on it, which cold and moisture vanish as fast as the steam, in its descent, takes place of the water; but if you force all the water out, the steam, or a small part thereof, going through P, will rattle the clack, so as to give sufficient notice to change the cocks, and the steam will then begin to force upon the other vessel, without the least alteration in the stream; only sometimes the stream of water will be somewhat stronger than before, if you change the cocks before any considerable quantity of steam be gone up the clack R: but it is better to let none of the steam go off, for that is losing so much strength, and is easily prevented by altering the cocks some little time before the vessel is emptied.

The wood-cut represents two reservoirs, P P, designed for *alternate* action; the tube E conveys water from the discharging pipe, to replenish the boiler L, when the water in it is almost consumed; and this is done by keeping D supplied with water, and (lighting the fire at B) generating a sufficiency of steam to press the water into L, through the pipe K. This will convey a tolerably correct idea of Savery's engine, and the mode of its operation. He gives no proportions of its parts, nor perhaps had he established any rule of action. He appears to have considered the strength of his machine to be the only limit to be observed; "for," says he, "I will raise you water 500 or 1,000 feet high, could you find us a way to procure strength enough for such an immense weight as a pillar of water of that height. But my engine at 60, 70, or 80 feet, raises a full bore of water with much ease."

Such was the machine which first solved the problem, which had so long occupied the attention of many ingenious and talented men, of employing the power of steam as an auxiliary to, or substitute for, the other sources of mechanical power then known. In simplicity of construction and of action,

erfect freedom from friction, the machine has never perhaps been lthough it was subsequently superseded by Newcomen's engine, when ired as a machine to raise water from great depths; yet from the its parts, and from its little liability to derangement, it was employed, until a very recent period, in cases where great power uired.

ontrivances were supplied by different persons, by which it was f-acting. In 1819 Mr. Pontifex of Shoe Lane, London, obtained a mprovements in this description, and erected an engine upon this the City Gas Works, which we shall subsequently notice.

Savery's invention proved of considerable utility, yet it possessed arent defects which greatly limited its sphere of action. The these defects were, first, the great strain to which the boilers and ls were subjected; for the force of the steam being exerted directly rface of the water to be raised, the pressure of the steam was re- ll cases to exceed that of the ascending column of water. The perhaps even greater, defect was the enormous consumption of fuel by the steam vessel at each successive discharge, being alternately e temperature of the steam, and cooled down to the temperature of

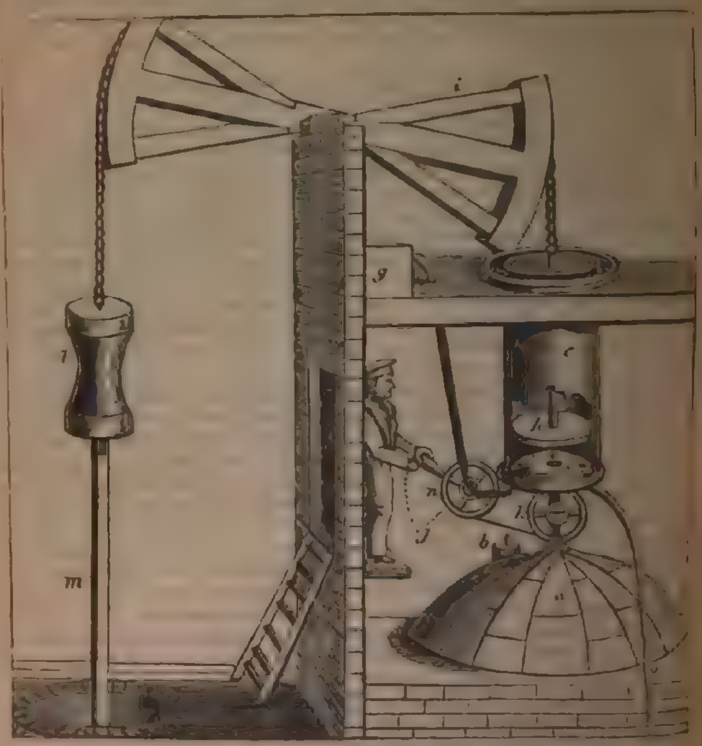
had Savery's engine been brought sufficiently into operation to call the defects we have noticed, when by a different application of principles, a machine of a totally different character was produced he first of these defects was completely obviated. This was the engine invented by Thomas Newcomen and John Cawley, the former a and the latter a glazier, in the town of Dartmouth, in Devonshire. f applying the pressure of the steam directly upon the surface of the employed the steam to produce by its condensation a vacuum iston, moving in a cylinder and exposed to the atmosphere, and the acquired they applied to work pumps through the intervention of y this arrangement, the pressure of the steam was not in any case exceed that of the atmosphere, as by assigning suitable proportions n cylinder and the pumps, or to the arms of the beam, they could ter to any required height.

t on the following page (from an old engraving), will perhaps assist comprehension.

nts the boiler; *b* the safety-valve; *c* the cylinder, open at the top, t the bottom, in which there are three holes, *d e f*; *e* the passage m the boiler; *d* admits a jet of cold water from the reservoir *g*, for ation of the steam; *f* the exit passage for condensed steam and e piston, working air-tight in the cylinder, by packing; *i* the beam d, for the purpose of transmitting the motion of the piston to the he mine.

nt quantity of steam being first formed in the boiler, the attendant handle or lever which he holds down to *j*, which, by the wheels and the cock *k*, and allows the steam to enter the cylinder. The steam sufficient to equal the pressure of the atmosphere, will not of itself n and loggerhead; it is therefore necessary that some means should to aid its ascent. This is done by means of the weight or counter- ot by the force of the steam and gravity of the counterpoise, the piston to the top of the cylinder, and forces down the pump-rod *m* into the e. When this is effected, the attendant returns the handle to its ition (shown in the cut), which prevents the admission of more steam ler, and, at the same time, opens the cock *n*, so as to admit a small old water from the reservoir *g* into the cylinder; this, by dispersing the steam, almost instantly condenses it, so that a void is at once d the pressure of the atmosphere meeting no longer with resist- upon the external surface of the piston, and, by its descent to the e cylinder, raises the pump bucket in the mine. The handle is ed to *j*, which allows fresh steam to enter the cylinder and elevate

the piston as before. To prevent the accumulation of water in the cylinder the eduction pipe *o* is of such length that the weight of a column of water



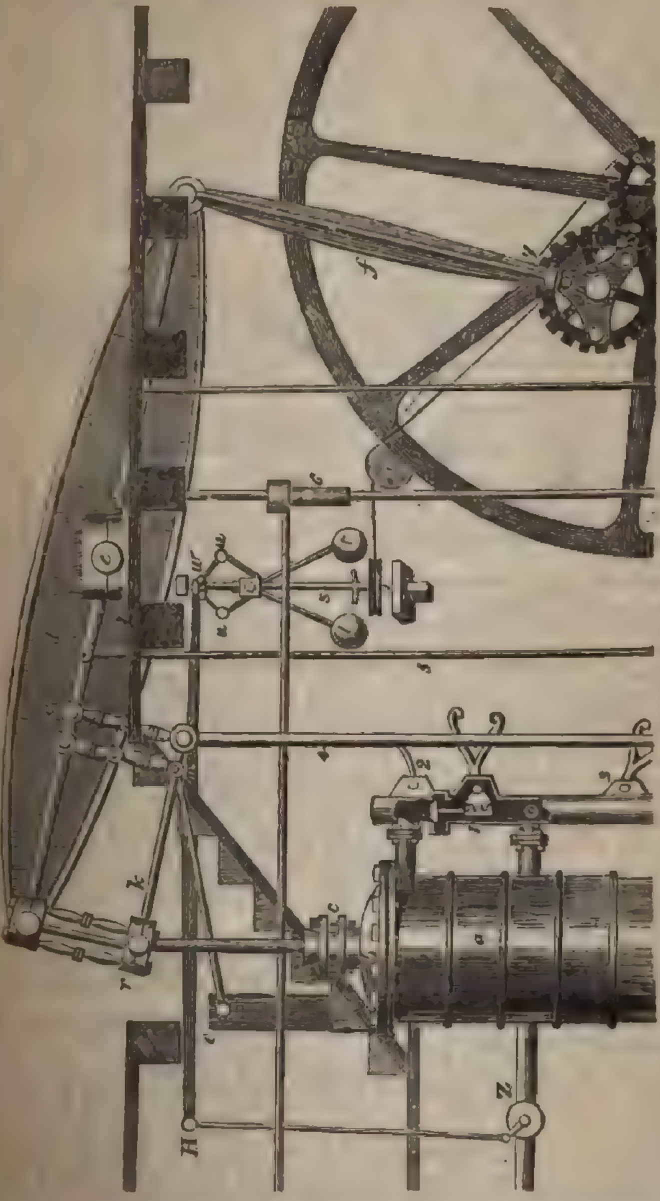
Newcomen's Engine, 1705

within it exceeds that of a column of the atmosphere; so that it runs off by its own gravity.

From the superiority of the principle of Newcomen's engine over Savery's it soon superseded the latter, and it came gradually into very general use for draining mines, receiving from time to time various important improvements in the mechanical details of the arrangement, from various ingenious persons, particularly the celebrated Smeaton. Our limits will not allow us to notice each of these as they occurred, we shall therefore proceed at once to the inventions of the great Watt, which completely altered the character of the engine, rendering it almost universally applicable, as a prime mover of machinery.

Prior to the introduction of Mr. Watt's improvements, the condensation of the steam in even the most improved arrangement of the atmospheric engine took place in the cylinder in which the steam operated, as it had done in its predecessor Savery's engine. The waste of fuel from this cause we have already pointed out, but in addition to this evil there was also a direct loss of power, owing to the vapour which was given out by the injection water, and which materially affected the vacuum. The attention of Mr. Watt was drawn to the subject about the year 1763. He was at that time a young man recently established in business at Glasgow, as an optician, and holding likewise the

ses the opposite end of the horizontal lever H, which acting on the lever nnected to it, opens or shuts (as it may be adjusted) the valve Z inside the

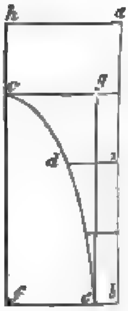


eam pipe, and diminishes or enlarges the area by which the steam flows into the cylinder. The fall of the balls when the motion decreases, reverses all

these movements, of course; and by thus enlarging or contracting the steam-way, and admitting more or less steam into the cylinder, the impulse of the piston is rendered much more uniform. The valve in this part of the steam-pipe is now called the *throttle valve*, and the regulating pendulum the *governor*

An important improvement of Mr. Watt's was carried into practice in 1778. It consists in shutting off the steam from the cylinder, some time before the piston has completed its stroke, so that the remainder may be performed by the expansion of the steam already contained in the cylinder. This serves as a method of regulating the acting force of the engine, because, as the steam can be shut off at any part of the ascending or descending stroke, so much steam may be admitted as barely to carry the piston through its required motion, and by the adjustment of the valve gear, the quantity of steam admitted may at all times be varied in an instant. If this were the only advantage, it is a great one; but it will be seen that a great saving of fuel will likewise be effected by this method.

We shall endeavour to explain this more clearly by the aid of a diagram. The pressure of steam, as ascertained by numerous and carefully conducted experiments, is so nearly in direct proportion to its density, that for practical purposes it may be assumed to be in that ratio; and its density is of course inversely as the space occupied by it. Having premised thus much, let *a* 1 *c h* represent a cylinder into which the steam flows during the whole period of the stroke; at the end of which, or when the piston arrives at 1 *c*, the steam is discharged from the cylinder; then the effect being as the pressure of the steam multiplied by the space through which it acts, which pressure is in this case the same throughout the stroke, if the line *a h* represents the pressure, and *a* 1 the space through which it acts, the area of the rectangle *a* 1 *c h* will represent the effect.



Now let *a b f h* represent another cylinder of the same diameter as the former, but four times as long, and let it be supposed that only the same quantity of steam is admitted as before, the steam being cut off when the piston has reached to the position *c* 1, which is only $\frac{1}{4}$ of the stroke in the cylinder *a b*; the piston will in this case continue to descend, but the pressure upon it will gradually decrease; and when the piston has made half its stroke, as the original volume of steam *a* 1 will then be expanded into double its bulk, or occupy the space *a* 2; its density, and consequently its pressure, will only be half as great as at the moment at which it was cut off, or when the piston was in the position *c* 1; therefore if the line *c* 1 represent the full pressure of the steam, the line *d* 2 will represent its pressure at the position 2. At the end of the stroke, or when the piston arrives at *f b*, the steam will be expanded into four times its original volume; consequently its pressure will then be only one fourth of its original pressure, and will be represented by the line *b e*.

In this case the total effect of the steam will be represented by the area *h c e b* 1 *a* which exceeds the effect of the steam in the first supposed case, by the area *c d e b* 1, which therefore represents the increase of power due to the expansive action of the steam.

The curve *c d e* represents the ratio in which the pressure of the steam decreases as the piston descends in the cylinder, and if we deduct the area included by the points *c d e f c*, from the area of the rectangle *c* 1 *b f*, we shall obtain the area of the figure *c e b* 1, which represents the effect of the expansive action. Now, as the curve *c d e* differs but little from a parabola, the mean pressure may be readily computed by the following rule. It is only an approximation, but it is sufficiently near the truth for all practical purposes, so long as the steam does not expand to more than four times its original volume, and within those limits gives a result rather below the true one.

Rule.—To the pressure of the steam, above the pressure of the atmosphere, add 15 lbs per square inch for the atmospheric pressure, and call the sum the

ressure of the steam; square the fraction of the stroke during which the acts expansively, and deduct $\frac{7}{10}$ of the product from unity, and the der, multiplied by the total pressure, will be the mean pressure, after ing 15 lbs for the pressure of the atmosphere in the case of non-con g engines.

ple in a non-condensing engine; suppose the pressure of the steam, at mmencement of the stroke, to be 45lbs per square inch above the here, and that the steam is cut off at $\frac{1}{4}$ of the stroke: required, the mean e of the steam.

Full pressure	45 lbs
osphere	15 . .
Total pressure	60 lbs
Steam cut off at $\frac{1}{4}$	·25 . .
Expands throughout $\frac{3}{4}$	·75 . .
Which is to be squared	·75 . .
	375
	525
	·5625
Deduct $\frac{7}{10}$	·7
	·39375
From unity	1.
	·60625
Multiply by total pressure	60 lbs
	36·37500
Deduct for atmospheric pressure	15
Mean pressure	21·375 lbs

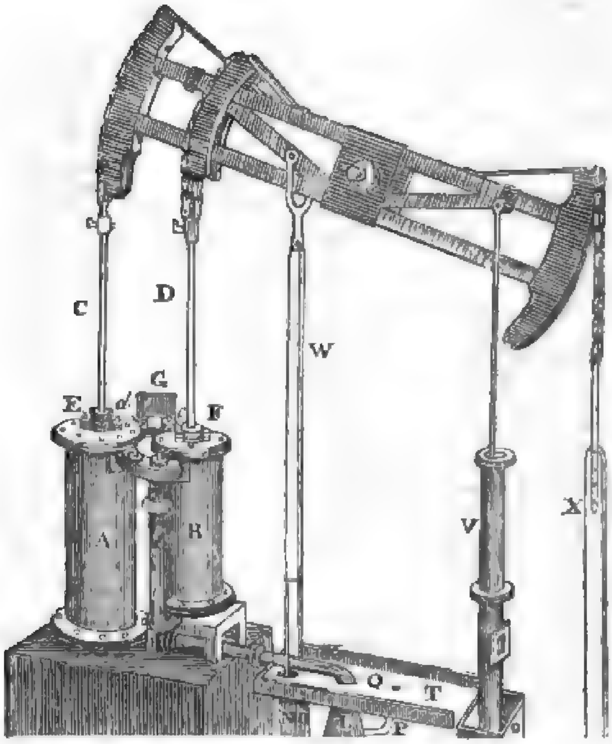
mechanical effect being as the pressure of the steam, and the space h which such pressure is exerted, the effect of the steam whilst acting at essure in the above example, will be as 45lbs through a space 1 = 45, e total effect will be as 21·375lbs through a space 4, which is equal to is nearly double the former, and shows the great advantage to be derived ing steam expansively. There are, however, in practice certain limitations extent to which steam may be allowed to expand, for independently of convenience of the great size of the cylinder when the expansion is d to an extreme, the pressure of the steam upon the piston should be less than the resistance from the friction, &c. added to the pressure of tmosphere in non-condensing engines, or the pressure of the non-condensed in condensing engines; but in the preceding example, the pressure e end of the stroke is merely equal to that of the atmosphere. Mr. old gives the following rule for ascertaining the point at which the steam be cut off, so as to produce the greatest effect:—

de the amount of the friction, &c. added to the pressure of the atmosphere, -condensing engines, or of the non-condensed steam of condensing s, by the pressure of the steam in the boiler, and the quotient will give oportion of the stroke at which the steam should be cut off.

mple.—The pressure of steam in the boiler being equal to 120 inches of ry, the loss from friction, &c. (reckoned as $\frac{2}{5}$ of the whole) is 48, which to 30 inches for the pressure of the atmosphere is 78, and this divided

by 120 gives $\frac{44}{100}$ as the part of the stroke at which the steam should cut off.

The principle of expansion was subsequently adopted by Hornblower, w in 1781 obtained a patent for an expansion engine, arranged as exhibited the accompanying cut, of which the following is a description extracted fr the *Encyclopædia Britannica.*



Let A and B represent two cylinders, of which A is the largest; a piston moves in each, having their rods C and D moving through collars at E and F. These cylinders may be supplied with steam from the boiler by means of the square pipe G, which has a flange to connect it with the rest of the steam-pipe. This square part is represented as branching off to both cylinders; *c* and *d* are two cocks which have handles and tumblers as usual, worked by the plug-beam W. On the fore side of the cylinders is represented another communicating pipe, whose section is also square, or rectangular, having also two cocks, *a b*. The pipe Y immediately under the cock *b* establishes a communication between the upper and lower parts of the cylinder B, by opening the cock *b*. There is a similar pipe on the other side of the cylinder A, immediately under the cock *a*.

When the cocks *c* and *a* are open, and the cocks *b* and *d* are shut, the steam from the boiler has free admission into the upper part of the small cylinder B, and the steam from the lower part of B has free admission into the upper part of the great cylinder A; but the upper part of each cylinder has no communication with its lower part. From the bottom of the great cylinder proceeds the eduction pipe K, having a valve at its opening into the cylinder; it then bend

downwards, and is connected with the condenser. Lastly, the pump-rods cause the outer end of the beam to preponderate, so that the quiescent position of the beam is that represented in the figure, the pistons being at the top of the cylinder. Suppose all the cocks open, and steam coming in copiously from the boiler, and no condensation going on in L, the steam must drive out all the air, and at last follow it through the valve Q. Now shut the cocks *b* and *d*, and open the escape-valve of the condenser; the condensation will immediately commence, and draw off the steam from the lower part of the great cylinder. There is now no pressure on the under side of the piston of the great cylinder A, and it immediately descends. The communication Y between the lower part of the cylinder B, and the upper part of the great cylinder A being open, the steam will go from the lower part of B into the space left by the descent of the piston A. It must therefore expand, and its elasticity must diminish, and will no longer balance the pressure of the steam coming from the boiler, and pressing above the piston of B. This piston, therefore, if not withheld by the beam would descend till it came in equilibrio, from having steam of equal density above and below it. But it cannot descend so fast, for the cylinder A is larger than B, and the arch of the beam, at which the great piston is suspended, is no longer than the arm which supports the piston of B; therefore, when the piston of B has descended as far as the beam will permit it, the steam between the two pistons occupies a larger space than it did when both pistons were at the top of their cylinders, and its density diminishes as its bulk increases. The steam beneath the small piston is, therefore, not a balance for the steam on the upper side of the same, and the piston B will act to depress the beam with all the difference of these pressures.

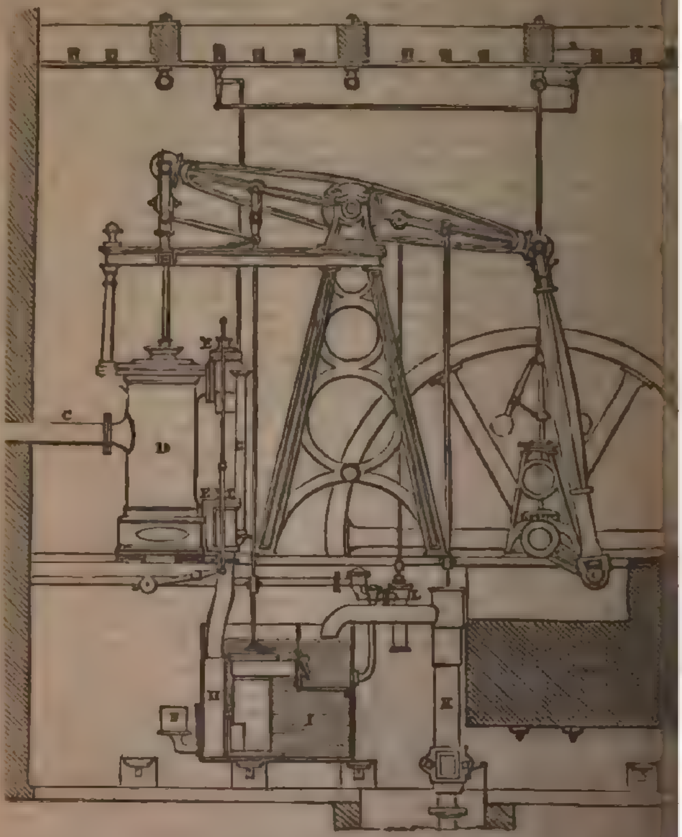
The slightest view of the subject must show, that as the piston descends, the steam that is between them will grow continually rarer and less elastic, and that both pistons will draw the beam downwards. Suppose, now, that each one had reached the bottom of its cylinder: shut the cock *a*, and the eduction valve at the bottom of A, and open the cocks *b* and *d*. The communication being now established between the upper and lower part of each cylinder, their pistons will be pressed equally on the upper and lower surfaces; in this situation, therefore, nothing hinders the counter-weight from raising the pistons to the top. Suppose them arrived at the top: the cylinder B is at this time filled with steam of the ordinary density, and the cylinder A, with an equal absolute quantity of steam, but expanded into a larger space. Shut the cocks *b* and *d*, and open the cock *a*, and the eduction valve at the bottom of A, the condensation will again operate, and cause the pistons to descend; and thus the operation may be repeated as long as steam is supplied; and one measure full of the cylinder B of ordinary steam is expended during each working stroke.

Professor Robison gave a series of elaborate and highly interesting calculations, by which, unluckily for the ingenious inventor, it was demonstrated, that the same effect only is produced in this, as in Mr. Watt's expansion engine; and these calculations were confirmed by the practice of those which Hornblower erected. Although he made an unsuccessful application to Parliament for an extension of the term of his patent, it does not appear that his engine obtained public patronage or approbation.

After the expiration of Watt's patent, the condensing engine, under the hands of different manufacturers, assumed a variety of forms. The accompanying cut represents a portable engine of 12 horse-power, as constructed by Messrs. Rothwell, Hick, & Rothwell, of Bolton.

This engine consists, in the first place, of a large cast-iron plate, firmly bolted to stone or brick-work, on which the whole of the materials are fixed. The beam with all its appendages is by this means supported, without being at all connected with the building, by a double diagonal frame, one half surmounted by an entablature plate, to which the bearers or spring beams are attached, that secure the studs or centres of the radius rod of the parallel motion, the extreme ends of which are supported by a pillar resting on a bracket projecting from the back of the cylinder. The pedestals in which the gudgeon of the beam works, rest on the entablature plate, and are firmly secured by bolts passing through the whole. The side walls on which the foundation plate acts are so

far asunder as to allow a sufficiently wide recess to receive the condensing c with its air-pumps and condenser, hot and cold water pumps, as well as to room for getting down to secure the ends of the bolts. The governor is ported by a standard placed directly over the crank shaft, and is turned single pair of bevel wheels. The upper part of it is hollow, to receive a



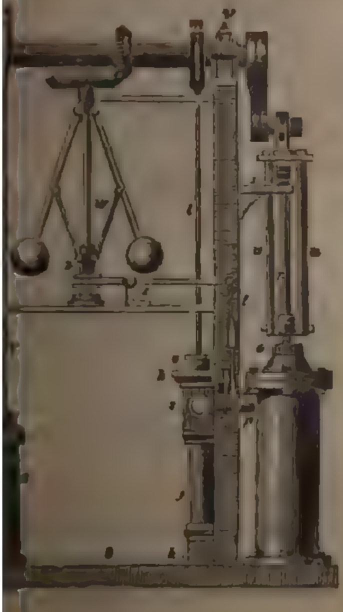
rod, that is attached by a cross pin to a brass sliding socket, which is con with the governor arms by two small links, and partakes of the motion co nicated to them by the movement of the balls. The small rod has a commu tion with the throttle-valves, by means of the levers fixed to the ceiling engine-house.

The kind of boiler attached to this engine is of the waggon-shaped kind, description of which has already been given at page 198 of the first vol this work.

The steam cylinder and its casing are cast together in one piece; the betwixt them is constantly filled with steam, which prevents any conden taking place within the cylinder, and serves also as a conducting-pipe steam to the boxes E, containing the sliding valves, (which are generally D valves, from their resemblance in form to that letter,) through two openings for that purpose, in each of which is placed a throttle-valve,

...les are levers, communicating by a rod with the governor, for regu... ...peed of the engine.

...ng-valves are packed on their circular sides with a soft substance of ...s, and in consequence of the steam being admitted to the under side ... valve, and the upper side of the bottom valve, they of course ... more force to move them than what is necessary to overcome ... of the packing, and the surface over which they slide. The ... the valves and their rods are accurately counterbalanced by a ...eight or a lever under the cylinder, and are moved by an ec...ele, on the fly-wheel shaft. By the arrangement of having two ...lves, the least difference in weight between those parts of the en... ...re attached to the opposite ends of the working beam can be regu... ...llowing a little more steam to pass in the same time through either of ... as may be found necessary,—thereby equalising, as much as possible, ... the engine. One pipe, G, only is required in front of the cylinder, ... the purpose of conducting the steam from the upper side of the ...he condenser. H, a vessel in which the condensation of the steam is ...er its escape from the cylinder, by admitting a quantity of cold water ...ondensing cistern I, through an injection cock, the opening of which ... by hand. The condensing cistern is supplied with water by the ...pump K. L is the hot water pump, used for raising water to supply ...which water passes through a small valve, and down the same pipe ...us the damper-float. This valve is connected with a lever, having one ... connected by a rod passing through a pipe with a stone float, that rises and falls with the surface of the water in the boiler, and thereby admitting a smaller or larger quantity of water, as may be requisite. This pipe, for the rod to pass through, has several advantages over the method of passing it through a stuffing-box on the boiler top; as, in case the hot water pump by any accident should cease to act, and the water get low in the boiler, the steam would make its escape before any serious injury could happen,—showing instantly that such was the fact, the moment it got below the end of the pipe. The friction between the rod and the water being so trifling, insures an almost uniform regularity of action. N, a small cistern, containing the blow-valve, for the purpose of allowing the air to escape from the cylinder, &c., previous to the engine being set to work.

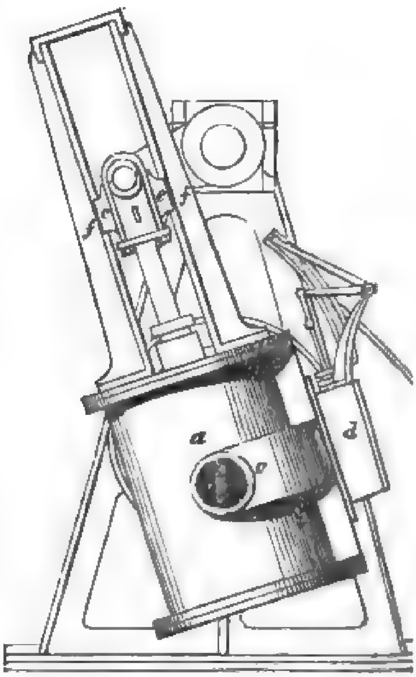


We shall now give an example of a common arrangement of the high pressure engine; in which, as no air pump is required, the beam is dispensed with.

h, the steam-pipe leading from the boiler, in which is the throttle-valve *i*; *j*, the

side-pipe, in which work the slide-valves *k k*, moved by the rod *l*, att to the eccentric *m*, on the shaft of the fly-wheel *n*. *o o o* are brass stuffing-b *p*, the upper steam entrance to the cylinder; *q r*, the piston-rod wo through the bridge *s*, and communicating with the crank *t* by the rods *u u*,—forming a very simple parallel motion; *v v*, pedestals su ing the main shaft, the revolution of which gives motion to a pa bevel wheels, and thereby to the governor *w*, the expanding or con ing of the arms of which raises or depresses the collar *z*, and acts o valve *i* through the medium of the lever 1 and handle 2; 4 is the pun supplying the boiler through a feed-pipe (not shown) worked by the rod 5 eccentric 6; 7 7 are the metal cheeks of the frame; 8, the metal foun plate, under which is a small cistern, (not shown,) containing a day's consum for the boiler. At the bottom of the side-pipe is an eduction-pipe, (not sh from which the steam is discharged into the cistern, to heat the water for plying the boiler after the steam has performed its office in the cylinder. periphery of the fly-wheel is round in its transverse section, and of cast iro arms or radii are of wrought iron, and are inserted into the former while ca

The subjoined figure represents an arrangement which is frequently ad for engines of small power; the cylinder is suspended upon axes or gudg and vibrates to and fro during the revolution of the crank, and hence engines are commonly called vibrating engines. The gudgeons are ho and form the steam and eduction pipes; *a* is the steam cylinder, *b* the h gudgeon at which the steam enters, and whence it passes by the channe the slide case *d*; and a channel similar to *c* connects the eduction passage with the other gudgeon, which opens into the condenser. The gudgeons project beyond the bearings in which they work; and their extremities pass through stuffing-boxes in the steam pipe and condensers; no connecting rod is required, but the piston rod is connected directly with the crank pin, and during the revolution of the crank the cylinder vibrates upon its gudgeons through an arc proportioned to the length of the crank. To the head of the piston rod is fixed a cap *e e*, which works between the guides *f f*, which are bolted to the cylinder cover, and thus take the strain off the piston rod in the oblique positions of the cylinder, and as the cylinder can be nearly counterbalanced on its axes in all positions, the strain upon the piston rod is never considerable.

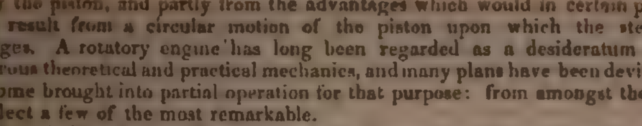


This arrangement is, we believe, the invention of Mr. Witty of Hull, obtained a patent for it June 5th 1813.

Partly from the erroneous notion that is extensively entertained, that is a loss of power in the employment of the crank to transmit the power

by the piston, and partly from the advantages which would in certain pur-
result from a circular motion of the piston upon which the steam
inges. A rotatory engine has long been regarded as a desideratum by
erous theoretical and practical mechanics, and many plans have been devised
some brought into partial operation for that purpose: from amongst these,
elect a few of the most remarkable.

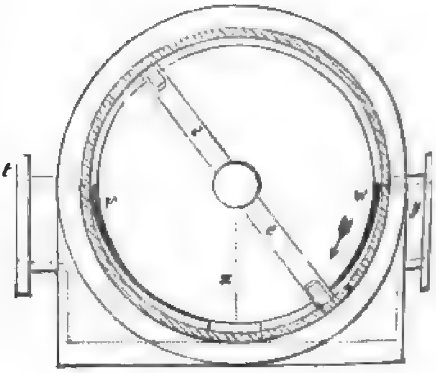
ricsson's Disc Engine. The accompanying figure represents a rotatory engine
nted by Captain Ericsson, which, although difficult to describe, so as to convey
ar idea of the way in which it operates, is alike remarkable for the fewness
s parts and the simplicity of its actions. It has no valves, the action of
piston upon the driving shaft is at all times direct, and the engine can be
ed or reversed at any position of the piston. *a a* is a spherical chamber formed

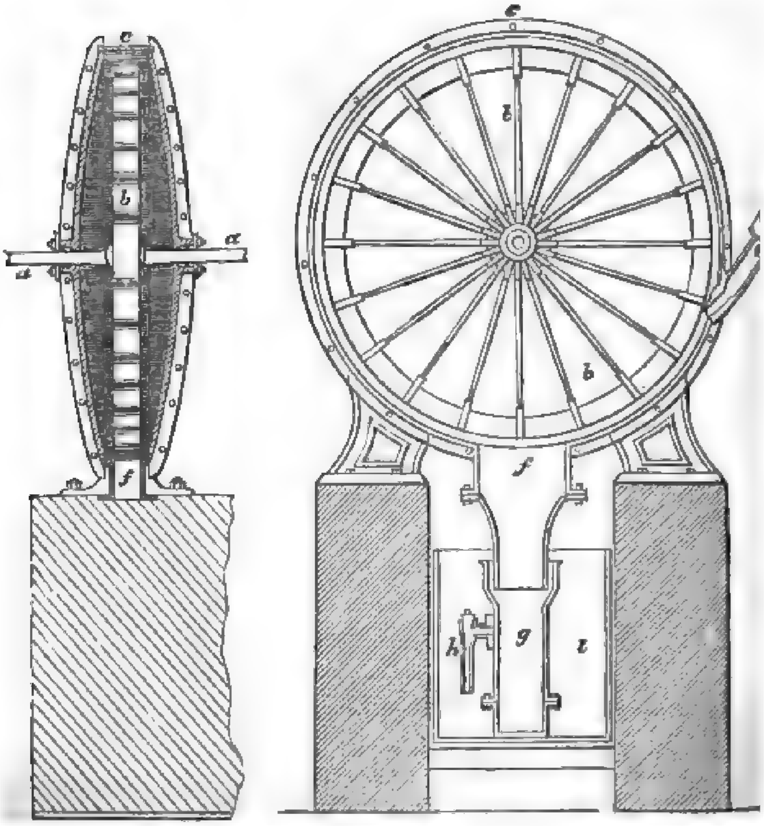


two parts, which are joined together by flanges, and bolted to an end plate or
er *b*, which is cast in one with the bed plate; *c* is the engine shaft, which
ses through the cover *b*, and has an obtuse cone *d* firmly fixed upon its end.
are two sectors or fans, fixed on to the cone on opposite radii, and fitted
h metallic packing *f* in their curved side: the cone *d* likewise has metallic
king *i* round its circumference. The sectors *e e* pass through slits *r* in a
c or circular plate *g*, the lower side of which is forced into close contact with
lower side of the cone, by means of a brass bearing *l*, which presses
ainst its axis *h*. The disc is retained securely in its position by a spherical
b on the end of the engine shaft, which works in a corresponding cup or
ket in the centre of the disc; and the revolution of the shaft causes the
c to revolve with it by the pressure of the sectors on the sides of the slits,
lower side of the disc remaining throughout the revolution in close contact
th the lower side of the cone. The slits in the disc gradually widen upwards
accommodate the continually varying angle which the sectors form with the
c during their revolution together, and to prevent the escape of steam past
ir edges they are lined with a metallic packing *r*; the disc is strengthened
thin flat arms *s s*, and has a metallic packing *k* round its periphery; the
per end of its axis works in a conical bearing *m*, governed by a set screw
e engine shaft works in conical bearings at *n n* governed by set screws *o o*.
Fig. 2. is an end section which will serve to show more clearly the manner
which the engine operates.

The steam passes through the neck *t* into the spherical chamber, through an
ning *v* cut through its side: this opening is of a triangular shape, and made
wide at the top as the circular plane is there distant from the base of the
e and gradually tapering off downwards; *w* is the opening through which
steam escapes into the atmosphere, or into the condenser (as the case
y be), through the neck *y*. The dotted line *z* shows where the cone and the
cular plane come in contact.

Steam being admitted into the spherical chamber by the neck *t* a opening *v*, and being there prevented from passing the line *x* by the pressure the disc against the cone at that place, it presses against the upper leaf *e*, which, together with the cone and disc, is thereby carried round in the direction of the arrow. When the leaf has passed the upper part of the opening *w*, the steam that has been acting upon it escapes into the condenser, or into the atmosphere; but at the same time the opposite leaf has passed the top of the steam opening *w*, which is carried round in a similar manner, and thus the motion is continued.





CORDER AND LOCKE'S ROTATORY ENGINE.

it be requisite that the engine should be capable of working with a re-motion, this may be effected by reversing the inlet and outlet passages of steam, by means of a four way cock, or a common slide valve.

rder & Locke's Breast-wheel Steam Engine.—This machine is extremely le in its construction, having neither piston nor valves, nor, in fact, any ing parts save the axle in its stuffing-boxes and bearings. According to statement of Mr. Josiah Parkes, C. E., who was appointed to examine and rt upon the performances of the engine, it is fully equal in effect to cylinder densing engines consuming the same quantity of fuel. Mr. Parkes further s, that if applied as an auxiliary to a condensing cylinder engine, by ing the eduction steam from the latter to pass through the rotatory engine re it arrives at the condenser, that an additional power equal to one third he power of the cylinder engine is obtained without any additional cost in , or increase of the air pump or condenser.

his engine consists principally of a wheel, revolving in an air-tight case, in communication with a condenser, and provided with air pumps, for keeping n exhaustion within the case.

he wheel is somewhat like an overshot water-wheel, *and does not touch any of the case.* It is turned by a jet of steam issuing from the steam-pipe of boiler, into the exhausted case, through a tube, which is inclined in the ction of a tangent to the circumference of the wheel, so that the steam inges against the buckets of the wheel and turns it round with great rapidity. shaft of the wheel passes through stuffing-boxes at the centre of the circular , and is supported externally by bearings.

he motion for the air-pumps is obtained from a small double-acting steam nder, independently of the rotatory engine.

g. 1 is an end view of the wheel, and a transverse section of the case, and 2 is a side view of the wheel, with the case in section; *a* is the engine shaft, revolving wheel, *c* the air-tight steam cases, *d* the steam pipe, *e* the throttle e, *f* the exhausting passage, opening into *g* the condenser, *h* the injection , *i* the cold water cistern. The exhausting apparatus is not shown.

alloway's Rotatory Engine.—The annexed *Fig.* represents a transverse section the engine, divested of such parts as are not required to explain its con-ction and mode of action.

a is a cylinder, which is supported upon a frame (not shown in the figure), closed at each end by a cover *b*, the internal surface of which is faced so o be a true plane; *x* is a smaller concentric cylinder, into which is keyed shaft *e*, and which therefore revolves with the shaft; *c* is a rectangular on firmly connected to the smaller cylinder *x*, and furnished round its sides metallic packing; *g g* are two sliders moving in steam tight cases *i*, and in tes formed in the cylinder covers; they form the steam abutments, and are n alternately within the slide cases, to allow the piston to pass by means cam on the shaft, which operates on cross heads attached to the slide rods, ch latter work in stuffing-boxes. After the passages of the piston the upper r descends, and is brought to rest upon the revolving cylinder *b* by its weight; the lower is pressed against the cylinder *b*, by a counterpoise: , 13, and 14, are the passages by which the steam enters the cylinder, and off to the condenser, or the atmosphere, as the case may be. These ges are connected with a steam chest, attached to the frame of the engine, furnished with a common slide valve, for the purpose of reversing the ne, as will be hereafter explained.

order to put this engine in motion, we will suppose that the slide in the chest is so arranged that the valves 6 and 7 are the induction valves, and d 14 the eduction valves. The piston being in the position shown, the 14 is then open to the condenser, and the valve 7 to the boiler, and the n rushing in between the upper slider, (which then forms the abutment) the piston, forces round the latter in the direction of the arrow. As soon as iston has passed the lower slider, the cam on the piston shaft recedes from ross head of the lower slider, and the slider is gradually forced up by its

counterpoise until it comes in contact with the shaft; the piston will the[…] G and both sliders shut, and only the two valves 7 and 14 open. As the[…] continues to revolve, the cams gradually open the upper slider and the va[…] and gradually close the valve 14, so that when the piston reaches the val[…] the former is completely shut, and the latter completely open, and whe[…]

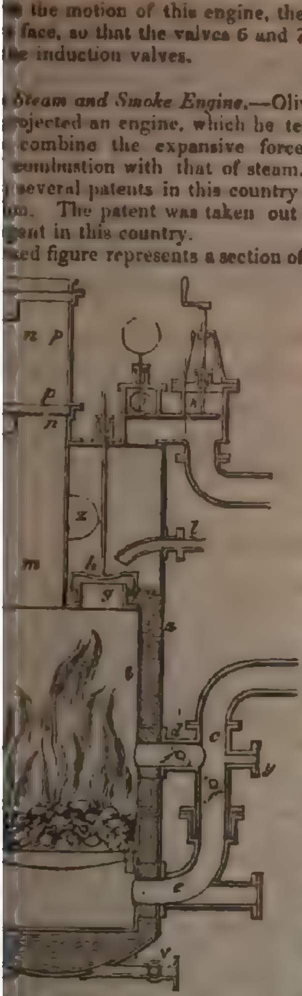
GALLOWAY'S ROTATORY ENGINE.

piston reaches the upper slider, it is completely withdrawn from the cyl[…] and thereby allows the piston to pass it. At this point, the steam is e[…] through 6, and escaping through 13, the lower slider being then the sl[…] upon which the steam acts. After the piston has passed the upper sli[…] cam allows the piston gradually to return to its place in the cylinder, an[…] the piston has passed the valve 6, that valve begins gradually to open, [..] valve 7 to close. Therefore when the piston has reached the pipe, the [..] slider is in its seat in the cylinder, the valves 7 and 14 are quite shut [..] and 13 quite open: the cam 4 then begins to give motion to the lower [..] before described, and the cam 10 to the valves, so that a constant rota[…] the axis is kept up.

the motion of this engine, the sliding valve in the steam chest is face, so that the valves 6 and 7 become the eduction valves, and the induction valves.

Steam and Smoke Engine.—Oliver Evans, the celebrated American projected an engine, which he termed a *volcanic* engine, wherein he combine the expansive force of the heated gases and other combustion with that of steam. Subsequently the idea has been several patents in this country: we select one of the most recent ion. The patent was taken out in the name of Mr. Hawkins, the gent in this country.

ed figure represents a section of the boiler. *a a* is a vertical cylinder constituting the shell of the boiler, *b b* a smaller cylinder placed within the former, and forming the furnace and ash pit: this is entirely surrounded with water. *c* is a tube connected with a blowing machine, and having two branches *d* and *e*, the former of which admits a portion of air above the fuel, and the latter a portion into the ash-pit, below the fire-bars: two throttle valves or dampers *f f* are provided to regulate the draft through each branch. *g* is a short cylindrical neck, through which the smoke and heated air pass into the steam-chamber, where they mix with the steam, and with it pass to the working cylinders. The neck *g* is covered with a valve *h*, opening upwards, the sides of which are turned down, to cause the heated air to pass through the water, and thereby give out a portion of its heat to the water: *i* the safety valve, *k* valve by which the pipe that conveys the steam to the engine can be closed when required, *l* the pipe by which the water is conveyed to the boiler, from the feed pump; the end of this pipe enters the boiler, and delivers the water on to the top



; this is with a view to prevent the valve getting excessively heated of the fire. *m*, is the chimney, or rather passage by which the eed into the furnace; on it is bolted a hopper *n n*, having at its at plate or sliding valve *o*, and another valve *p* at its lower end; lide in grooves, and are moved by means of a rack and pinion; ed on their seats so as to form an air-tight joint, and during the he engine is in operation, the chimney is kept closed by one or valves. To kindle the fire before starting, the valves *o* and *p* are and a quantity of lighted fuel put in first through the hopper, and ed upon it, and when the whole is thoroughly ignited, the valve d the blowers set in operation. When the engine is set to work, antity of air into the furnace both above and below the fuel at which having no vent to escape but the valve *h*, accumulates in the its pressure somewhat exceeds that of the steam upon the valve *h*, e valve, and rising up through the water mixes with the steam,

and passes along with it to the engines. *t* is a slider, by opening which the ashes from the furnace can be withdrawn; when this is requisite the dampers *f f* must be first closed. *v* is the blow-off cock by which the water can be discharged from the boiler when required, and *w* is a hole covered by a door, for removing any mud, &c. which may have accumulated: at *x* is a glass gauge to show the height of the water in the boiler, and at *y* is a glass eyepiece, through which the state of the fire can be ascertained, and *z* is the man-hole by which admission is obtained into the boiler.

STEAM NAVIGATION, the navigating or propelling vessels by steam.—In treating this subject we have, for the sake of perspicuity, and for ease of reference, divided it into the following sections:—

Section I.—Historical Outline of the Rise and Progress of Steam Navigation.

Section II.—The construction and arrangement of Steam Vessels.

Section III.—The construction and arrangement of Marine Engines, Boilers, Condensers, &c.

Section IV.—The construction and arrangement of the Propelling Machinery.

Section V.—On the Prevention of Accidents from Explosion, Collision, Fire, Foundering, &c.; with the Legislative Enactments on the subject.

SECTION I.

HISTORICAL OUTLINE OF THE RISE AND PROGRESS OF STEAM NAVIGATION.

Early writers and projectors; Dr. Allen.—Hulls.—Fitch.—Rumsey.—Miller.—Symington—his first Boat—his second, the "Charlotte Dundas."—Fulton.—Livingstone.—Fulton's first, the "Clermont"—First voyage by steam.—Fulton not the inventor of Steam Navigation, nor the first who established it.—Ordinary arrangement of Scotch steam boats. David Napier's steam packet.—The "Enterprise's" voyage by steam to Calcutta.—Auxiliary Steamers.—Auxiliary propellers applied to the "Maria," "Emerald," "Sarah Sands," "Amphion," and "Arrogant" steam frigates. Table of dimensions of some of the largest steam vessels yet constructed.

From the immense importance of the application of the power of steam to the purposes of navigation, the honour of originating it has been as keenly contested as the invention of the steam engine itself, and it is as difficult in the one case, as in the other, to fix upon the individual to whom the palm can be justly awarded. In fact, both the steam engine, and this application of it, must each be considered as the result of successive discoveries, to which even unsuccessful attempts contributed something, by the experience acquired, and various phenomena they brought to light. We shall not, however, attempt to notice every obscure hint and crude suggestion on which claims to the merit of the invention have been advanced in favour of various individuals, but shall briefly advert to some of the leading facts in the rise and progress of this most important invention.

The first clear and distinct announcement of a practical plan for propelling vessels by steam of which we are aware, is contained in a work entitled "Specimina Ichnographica, or a brief narrative of several new inventions," which was published by a Dr. John Allen in 1730. The first chapter describes various plans for economising fuel, by placing the furnace and flues within the boiler, so that they should be surrounded by water, as in the boilers of steam vessels of the present day. The second chapter contains a plan for moving ships in a calm. The Doctor notices several inventions which had previously been proposed for the purpose, and observes that in them "the motion was communicated by machinery working *without* the ship, something analogous to oars or paddles, or by the revolution of wheels turned by a capstan, placed within the ship;" on the contrary, no part of the Doctor's

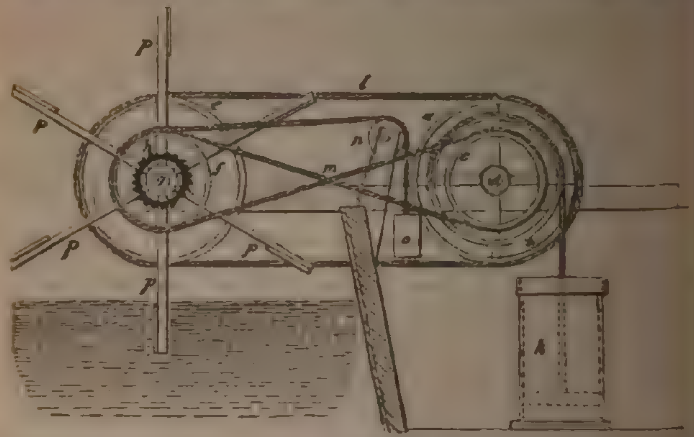
s placed outside of the vessel. His method was to form a tunnel or pipe, en at the stern of the vessel, and, by means of a pump, to force water or air rough it into the sea; and by the reaction which this would occasion, the p would be driven forward; thereby accurately "imitating what the thor of nature has shown us in the manner of swimming of fishes, o proceed in their progressive motion not by any vibration of their fins as s, but by protrusion of their tails; and water-fowls swim forward by ddling with their feet behind their bodies." The Doctor carried his scheme o practice on a canal, with a boat of considerable dimensions, and worked pumps by manual labour, but suggested the employment of a steam engine that purpose, and its application to a vessel of 1500 tons burthen. This oject has been subsequently repeatedly proposed, and has even formed the bject of several patents, owing to the ignorance of the parties soliciting em.

We repeat that, in our opinion, this may be regarded as the first distinct nouncement of a plan by which vessels would be propelled by steam. apin had proposed a plan, but it could not be carried into effect in the im- rfect state of the engine described by him; and Savery, who also suggested e application of steam to move vessels, pointed out no method in which the ower of steam was to be applied. But Dr. Allen's plan only required the plication of machines already known and used for other purposes, for it could ave been carried into effect by either Savery's or Newcomen's engines. The ode of propelling too is extremely ingenious; and although it may not be so ficient as that at present employed, we think that in the imperfect and rude ate of mechanical knowledge at that time, it would have proved in practice as fectual as any which could be suggested. It had this advantage, that it did ot require the conversion of a rectilinear motion into a rotatory one; most of e modes of effecting which, then known, were extremely inconvenient. It ad also this further advantage, that the machinery was not exposed to the rce of the waves or wind, and would not retard the vessel when sails alone ere employed.

A few years after the publication of Dr. Allen's pamphlet, Jonathan Hulls vised a different mode for applying the power of a steam engine to navigate vessel, and obtained a patent for the same in 1737. The letters patent, and description of his plan, were published in a tract by Hulls, in the same year, nder the following title, "A description and draught of a new invented achine for carrying vessels, or ships, out of, or into any harbour, port, or river, gainst wind or tide, or in a calm." His plan was to impart a rotatory move- ent to a paddle wheel (placed at the stern of the boat) by means of an mospheric engine. Mr. Galloway, in his History of the Steam Engine, says at Hulls proposed to obtain a rotatory action of the wheel, from the alter- ating action of the engine, by means of a crank; but this is a mistake, as will seen from the annexed sketch of his plan, which, although extremely genious, was certainly not so simple as the crank movement. In order to ow the parts more clearly, we have drawn those wheels which are placed on e same axis of different sizes, although, in the original, they are all shown of ual size.

a b c are three wheels firmly fixed on an axis *d*, and *e* and *f* are two loose eels, on another axis *g*; the wheels *e* and *f* have ratchets *h*, so that they ve the axis *g* only when they move in a forward direction; *k* is an atmo- heric engine, the piston of which is suspended from the wheel *b*; from the eel *a*, a rope *l* proceeds to the wheel *e*, and a rope *m* proceeds in a reverse ection from the wheel *c* round the wheel *f*, and another rope attached to the eel *f*, coming over the pulley *n*, has a weight *o* attached to the end of it; s weight should be a counterpoize to about one half the effective pressure on the piston of the engine. Upon the axis *g* are fixed a number of arms , to the extremities of which are attached paddles or float boards. The ent of the piston carries round the wheels *a b c* in a forward direction, and rope *l* drags the wheel *e* round in the same direction, and with it (by means e ratchet) the axis of the paddle wheel. In the mean time the rope *m* has

dragged the wheel *f* round in a reverse direction, and has raised the weight. At the termination of the stroke of the piston, the weight *o* descends, and continues the rotation of the paddle wheel, and at the same time, raises the piston



to the top of the cylinder. Thus a continuous rotation of the wheels, with an equable force, is obtained from the rectilinear and intermitting action of the engine.

Both Allen's and Hulls' plans were sufficiently clear and explicit, and had they been judiciously carried into execution, even with the means then at command, must have been attended with a moderate share of success, but neither were acted upon, and for nearly half a century, the subject of steam navigation seems to have remained in abeyance. But during this interval, Watt had introduced his stupendous improvements in the steam engine, by which he not merely augmented its effectiveness, but also, infinitely enlarged the sphere of its applicability, by showing that its utility was not limited to the draining of mines, to which purpose alone it had been hitherto confined, but that it was universally applicable as a prime mover of machinery.

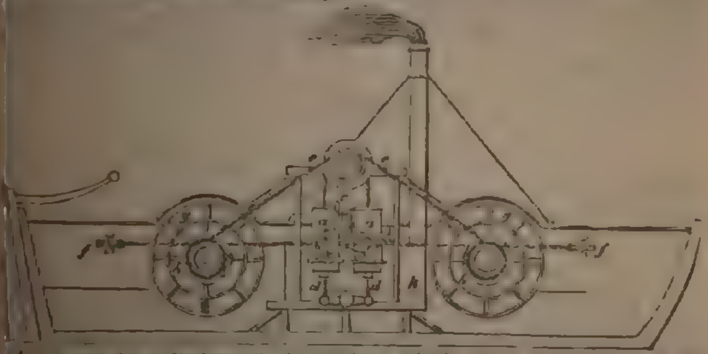
As men became acquainted with the powers of the engine in its improved form, it was gradually called into requisition for various purposes, and attempts to apply it to propel vessels seem to have been instituted at nearly the same period in various countries.

About the year 1783, Mr. John Fitch, an American, appears to have succeeded in moving a boat on the Delaware by paddles worked by a steam engine; and he subsequently constructed another vessel of larger size, [illegible] ultimately the scheme was abandoned.

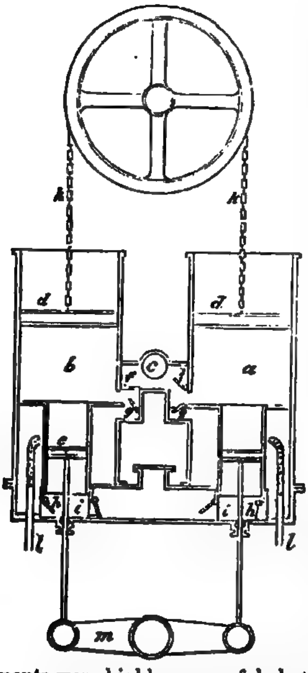
Contemporaneously with Fitch, a Mr. Rumsey of Virginia appears to have been occupied with the idea of navigating by steam. In 1787 he made two short trips upon the Potomac, in a vessel about fifty feet long, which was propelled by pumps worked by a steam engine—the plan (as we have [illegible] seen) originally proposed by Doctor Allen. The experiment being eventually given up, he came to England, where he found parties to advance the funds for another experiment; and although he unfortunately died before the whole of the arrangements were completed, the vessel was got afloat early in the year 1793, and made several trial voyages on the Thames, realizing, it is said, a speed of four knots an hour against wind and tide. If this were really the [illegible] it seems inconceivable that the attempt should have been relinquished (as it unfortunately was), for such a performance could scarcely be deemed a failure at that period, especially if considered as a first attempt.

It has been stated, that the earliest attempts to propel vessels by steam power in this country were made by Mr. Miller, at Dalswinton, in Scotland. [illegible]

re is some ground for believing that Mr. Miller's agency was rather in the aracter of a patron, than that of an inventor. It seems that Mr. Miller, in 1787, blished a description of a triple boat moved by wheels, with which he had n experimenting, to ascertain the comparative velocity with those moved by inary oars; and in this pamphlet he observed that the power of steam ght be employed to give them a quicker motion. A similar suggestion has en attributed to Mr. Taylor, who was a tutor in the house at Dalswinton, and which he has been regarded, by some writers, as the inventor of steam vigation. Under the impression that such was the fact, Lord Brougham vocated the claims of the widow of the late Mr. Taylor, and succeeded in aining a small pension for her, in consideration of her husband's public rvices. A third claimant, however, having a better title to the honour of iginating this important invention, appears in the person of Mr. Symington, o was introduced to Mr. Miller in the early part of his experiments on the mparative merits of oars and paddle wheels; and by which of these three entlemen the idea of applying steam power to move the paddles originated, quite immaterial. But it is not questioned that Symington actually applied s steam engine to turn Miller's paddle wheels, attached to a twin boat, lying a lake near Dalswinton-house. Symington had previously obtained a patent r his steam engine, and shown its application in a small model of a steam rriage. The transition of turning the wheels of a boat, instead of those of a rriage, was so easy and obvious, that Symington did it out of hand, and made veral trials of it in 1788, which proved so satisfactory, and so delighted Mr. iller and his numerous visitors, that he immediately determined to commence other boat on a greater scale than the first. The machinery required for this rpose was constructed at the Carron works, under the direction of Symington, d was applied to a double boat sixty feet long, which had been used for iller's previous experiments. A trial of this vessel was made on the Forth and yde canal, in October 1789, and was found so efficacious, that she glided rough the water at the rate of nearly six miles per hour. The mechanical rangement of this vessel was precisely the same as the former, the only teration being its increased dimensions, affording strong presumptive evidence practical success, and hence rendering a description of its construction of e deepest interest in a scientific point of view; which we shall now proceed give, with reference to the annexed sketch, which represents a longitudinal ction of the vessel and its machinery.

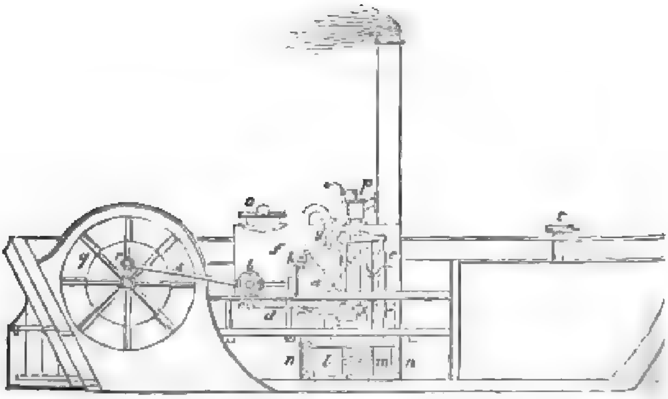


A: *a a* are the cylinders of the engines, which are a modification of the mospheric engine as patented by Mr. Symington; *b b* are the nozzles; *c* the ay beam for working the valves; *d d* the air pump rods; *e e* connecting chains; *f* direction pulleys; *g g* the paddle wheels, situated and wrought in a trough, tending from the stem to the stern of the boat, and allowing free ingress d egress to the water; *h h* ratchet wheels, for communicating motion to the ddle wheels. The level of the water is expressed by the horizontal line *i d*; the boiler is at *k*.



To avoid trenching upon the s claims set up by Mr. Watt in the s tions of his patents, Mr. Symingt compelled to resort to several pecul trivances; which we shall proceed tc by the annexed enlarged section engine only, taken from Mr. Syn Junior's, account in the Mechanic's Ma It had two cylinders open to the atm at the top, and each cylinder had two the lower ones acting as air pumps: are the cylinders; *a* being in the receiving, and *b* of condensing the *c* the steam pipe; *d d* atmospheric producing, by their alternate action ratchet wheels, a rotatory motion; the exhausting pistons; *f f* steam valv exhausting valves; *h h* foot valves; charge valves; *l l* injecting pipes; *m* the

Notwithstanding the decided suc the experiment, Mr. Miller, most tunately, suddenly abandoned the s and Mr. Symington, not having the ne funds himself, was unable at that t follow it up. In 1801, however, he menced a series of experiments on the and Clyde canal, under the auspices o Dundas, of Kerse, with the view of subst the power of steam for that of in towing vessels on canals. These e ments were highly successful, but the proprietors of the canal, apprehe that the undulation created in the water by the paddle wheels would inju banks, would not adopt the plan, and to crown Mr. Symington's disappoint the Duke of Bridgewater, who was in treaty with Mr. Symington for th struction of eight tug vessels for the use of his canals, died about the same Mr. Symington receiving the news of his death on the same day that the de of the canal proprietors was notified to him. These accumulated disap ments appear to have been too much for his spirit, and he retired fro pursuit in despair.



The cut above represents a partial section of the *Charlotte Dundas*, o the vessels constructed by Mr. Symington for Lord Dundas, and which i

...h, 1803, towed two laden boats, of 70 tons each, a distance of ...g the summit level of the canal, at the rate of 3½ miles per hour, ...reeze right a-head. The vessel was fitted with a cylinder of 22 ...r, and 4 feet stroke.

... cylinder, placed horizontally; *b* friction rollers supporting the ...he piston rod; from the underside of the cross head short arms ...hich are attached side rods *d*, giving motion to the bell crank ...rks the air pump rod, as also the plug frame *e*, which regulates ...he boiler; *g* the steam pipe; *h h* the steam valves; *i i* eduction ...ction pipe; *l* the condenser, which, with the air pump *m*, is ...stern *n*; *o* is the man-hole; *p* the safety valve; *q* the paddle ... in a cavity in the centre of the stern of the vessel, which was ... behind to the water; *r* the crank; *s* the connecting rod. The ...d by two rudders connected by iron rods, and wrought in the ... vessel by the steering wheel, *t*.

...me that Symington retired heart-broken from the field, a new ...eared upon it, who was destined to achieve for steam navigation ...which it never after receded, but on the contrary, has progressed ... present time. This was the celebrated Fulton, who, by his ...severance, finally overcame the difficulties of all kinds which ... the undertaking, and is generally, and in one point of view ...justly, considered the inventor of steam navigation.

... was born in Pennsylvania, came over in 1786 to England, where ... reside many years, during which time he became known to the ...water, Earl Stanhope, Dr. Cartwright, and other individuals ... or taking an interest in, steam navigation, with some of whom he ...upon the subject. In 1796 he proceeded to Paris, where he ...ted with Mr. Livingstone, then minister from the United States ...overnment. Mr. Livingstone had been engaged in some expe...n navigation in America, and, impressed with the importance of ... his native country, he advised Fulton to turn his mind to the ...s agreed between them to embark in the enterprise, and imme... such experiments as would enable them to determine how far, ...er failures, the object was attainable, and to Fulton was left the ...tion of these experiments. In the course of these experiments, ...cipally made with small models, he tried many of the modes of ...ich had been at various times proposed, as pumps, endless chains ... He likewise appears to have returned to England for a short ...ve visited Mr. Symington, whilst the latter was engaged in his ... the Forth and Clyde canal; and it is stated that Mr. Symington, ...got up the steam on board the vessel, (the *Charlotte Dundas*,) ... with Mr. Fulton on board, about 4 miles and back, and that he ...llowed Mr. Fulton to take notes and sketches of the boat and .... Fulton finally decided in favour of paddle wheels, and pro...struct an experimental vessel on the Seine. The length of the ...eet, and her width 8 feet, and in the autumn of 1803 he made ...rom which he acquired such confidence, that orders were trans...on and Watt to prepare a steam engine to be sent to New York, ...rned to England to watch its progress. In 1806 he returned to ...struct the vessel, and in the spring of the year 1807, she was ... the engine was fixed in her by Boulton and Watt's men. This ...nown will outlive that of the Argo, was named the *Clermont*; she ...ng, 7 feet deep, 18 feet wide, and 160 tons burthen. The steam ...2 feet diameter, with a 4 feet stroke; the paddle wheels were ...eter, the floats were 4 feet wide, and dipped in the water 2 feet. ...autumn the vessel started on her first trip which was to Albany, ...0 miles, which distance she accomplished in 32 hours. The ... performed in about the same time, and both in going and ...ind (a light breeze) being ahead, the whole was performed by

This triumphant experiment established Fulton's reputation; and since then, this fine vessel plied between New York and Albany as a passage boat. Her success was such, that a new vessel of larger dimensions, and of greater proportionate power, was commenced during the same year. From that date steam navigation was firmly established in America, and went on extending with astonishing rapidity. Fulton in consequence realized large sums, but his prosperity was not without alloy, and he was doomed to experience the lot of most mechanical inventors, who are too frequently exposed to mortification, as well by the success as by the failure of their schemes. No sooner had he established the practicability of his plans, than attempts were commenced to infringe upon or evade his patent; and he was from that time continually engaged in a series of lawsuits, to protect his hard-earned privileges. In consequence of the expense attending these proceedings, and that of the experiments he was constantly engaged in, although he lived without ostentation or extravagance, his affairs after his death (which happened in February 1815) were found to be excessively involved; and it is to be feared that his family reaped but little benefit from his meritorious labours, which have been productive of such signal benefit, not only to his own country, but to the world at large.

Although we have said that in one sense Fulton may be considered the *inventor* of steam navigation, we feel that this is not exactly the position which he occupies in relation to this invention, and we use the term for want of one as compendious, and at the same time more accurate. Strictly speaking, Fulton cannot be said to have contributed anything to the invention. As regards the mere idea of moving vessels by steam, Dr. Allen and Hulls had each invented and published practicable plans, by which it might be effected, more than 70 years prior; neither was he the first to attempt to realize these schemes, either here or in his own country; and if it be said that he was the first who attained complete success, we reply that both Symington and Rumsey had fully triumphed over the mechanical difficulties of the task, and the invention was completed before he took it in hand. And yet, notwithstanding that this is (we think) undeniably true, it is in our opinion equally true that to him we owe the gift of steam navigation, with the various blessings which it has bestowed. Although the invention had been completed by others, it might be considered as lost to society, which did not appreciate its value, until Fulton by his untiring energy and perseverance, practically demonstrated its transcendent importance, and forced conviction upon his ignorant and incredulous contemporaries. In corroboration of this view of the subject, we would add, that notwithstanding Symington's successful labours, it was not until nearly 10 years after their termination that the first steam boat was established in Great Britain, and then principally in consequence of the notices which from time to time appeared of the progress of steam navigation in America.

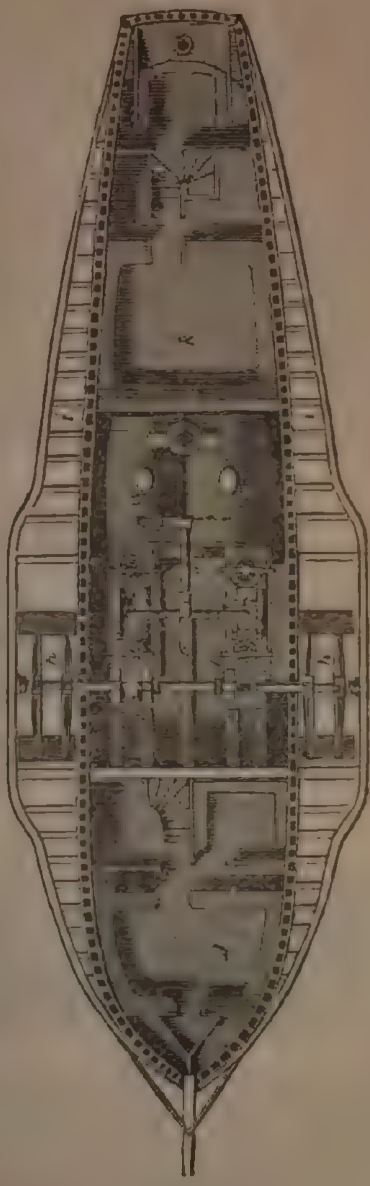
On the next page are given engravings of the arrangements of a Scotch steam boat, which is common on the river Clyde. *Fig.* 1 represents a longitudinal and vertical section, from stem to stern; and *Fig.* 2 a plan of the same, showing the deck removed. Similar letters in each figure refer to corresponding parts. At *a a* are the boilers; *b* the chimney, leading from the flues of both the fires; *c* is the steam pipe, which receives the steam from both the boilers, and conveys it by a cross tube to the two cylinders *d d*, through the valve boxes at *f f*. The air pumps *e e* are worked by the main-beam, and the eccentric, for giving motion to the valves, is shown at *g*. *h h* paddle wheels; *i* one of the paddle boxes in section. At *j* is the fore cabin, *k* the after cabin, *o o* the staircases, *l l l* the framing of timber, which supports a platform or deck, (commonly called the gangway,) which nearly surrounds the hull of the vessel.

No attempts were made, we believe, to perform sea voyages by steam boats, until the year 1818; when they were established by Mr David Napier. Shortly afterwards, the Irish mails were conveyed between Dublin and Holyhead by regular steam packets.

At length the longest voyages were attempted by steam. In the year 1825 the *Enterprise*, a vessel of 470 tons burthen, and 120 horses. power, sailed to

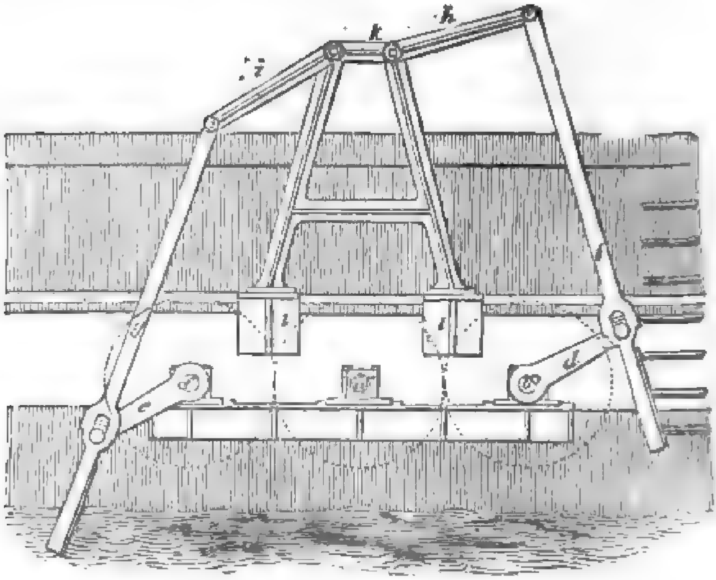
Fig. 1.

Fig. 2.



India. She left the land on the 16th of August, and reached Calcutta, Dec. 7, 1825; being 113 days from the land to Diamond Harbour. She used both sails and steam. The greatest run by sail in 24 hours was 211 miles; the least 39 miles. The greatest run by steam, assisted by sail, was 225 miles; the least 80 miles. She steamed 64 days, and the rest of the time was under sail. The consumption of coal was 580 chaldrons, or about 9 chaldrons per day. She rendered essential services to our arms during the Burmese war.

A recent application of the power of steam, which is calculated to be of signal benefit to the commercial marine of this country, is the employment of it on a limited scale as an auxiliary to shipping during calms and light airs. One of the first vessels in which steam was so applied was the *Maria*, of 460 tons register, which sailed to Bombay. She was fitted with a propelling apparatus, the invention of Mr. J. Melville, and designed principally for the purpose of propelling sailing vessels in calms, to which purpose, it appears to us to be extremely well adapted. The annexed figure shows an elevation of the apparatus as applied to the *Maria*. *a* is the engine shaft, situated between the two propelling shafts, *b* and *c*. These three shafts are caused to revolve together with equal velocities, by means of three spur wheels, of equal diameter, fixed one upon each shaft within the vessel; and therefore shown by dotted lines. Upon the outer ends of the shafts *b* and *c* are fixed the cranks *d* and *e*, in diametrically opposite directions, so that they remain constantly parallel to each other; but whilst one crank is ascending, the other is descending; *f* and *g* are the propelling levers, or stems, to the lower ends of which the floats *m* and *n* are attached. These levers turn upon the pin of the propelling cranks *d* and *e*, and are guided in their motions by the radius rods *h* and *i*, connected to their



upper ends. The radius rods are connected to a cast iron frame, *k*, which is supported on two brackets, *l l*, attached to the side of the vessel. The principal dimensions of the apparatus are as follows:—

	Feet	In.
Diameter of cylinder	0	10½
Length of stroke	2	0
Diameter of the spur wheels at the pitch lines . .	4	10

	Feet	In.
Diameter of the paddle cranks	3	0
Breadth of paddles	2	0
Depth of ditto	2	0

Subsequently to the instance of the *Maria*, numerous vessels have been fitted with auxiliary steam power; and "auxiliary steamers" are now employed on several trading lines. These being built expressly for the purpose, have, in most cases, screw propellers. Amongst the largest of these vessels is the *Antelope*, of 600 tons, and the *Emerald*, of 700 tons, and 50 horse power, trading between London and Belfast; and the *Sarah Sands*, of 1000 tons, trading between Liverpool and Rio Janeiro.

The government likewise appear to appreciate the advantages which may accrue to the navy from the application of steam as an auxiliary. In addition to several guardships at the different ports so equipped, the *Amphion*, 36 gun frigate, of about 1500 tons burthen, has been fitted with a screw propeller, driven by engines of 300 horse power. By means of this steam power, she can, it is stated, command a speed, under ordinary circumstances, of nearly 7 knots per hour under steam alone; and with steam and sail combined, a speed which in all cases shall render her superior to every other mere sailing ship she may meet with. Another "auxiliary" frigate, the *Arrogant*, of 1850 tons and 360 horse power, with a screw propeller, is building.

The following Table contains some of the dimensions of the hull and machinery of some of the largest steam vessels yet built.

DIMENSIONS.	Great Western.	Terrible, Steam Frigate.	British Queen.	President.	Great Britain.	
Extreme length	236	—	275	265	322	feet.
Ditto, under Deck	212	—	245	238	—	„
Ditto, Keel	205	220.2	225	270	289	„
Breadth within the Paddle Boxes	35.4	42.6	40	41	51	„
Ditto, including ditto	59.8	—	64	64	—	„
Depth of Hold at Midships . .	23 2	27.4	27.6	25.6	33	„
Tons of Space	679½	—	1053	—	1000	tons.
Tonnage of Engine Room . .	641½	—	963	—	—	„
Total Tonnage	1321	1850	2016	1840	3443	„
Power of Engines	450	—	500	540	—	horses.
Diameter of Cylinders	73	—	77½	80	4 of 88	inches.
Length of Stroke	7	—	7	7½	6	feet.
Diameter of Paddle Wheels . .	28.9	—	30.6	31	—	„
Total weight of Engines, Boilers and Water	480	—	500	500	740	tons.
Total weight of Coals, 20 days consumption	600	—	750	750	1000	„
Total weight of Cargo	250	—	750	750	—	„
Draught of water with the above weight of Stores	16.8	18.9	16.7	17	16	feet.

SECTION II.

THE CONSTRUCTION AND ARRANGEMENT OF STEAM VESSELS.

Differences between Steam and Sailing Vessels.—Form and Proportions.—Resistance.—Beaufoy's Experiments.—Russell's Experiments.—Remarkable deviations from the assumed law of velocity.—"The solitary wave of progression" not dependent upon form or velocity, but on the depth of the fluid.—Mr Houston's accidental discovery of a diminution of resistance at certain increased velocities of motion.—Form of vessel of least resistance.—The "Wave-lines" of.—Sir J. Robison's Experiments.—Mr. Oldham's suggestion for improved experimental apparatus.—Tables showing results of experiments.—Proportion of power to tonnage or admeasurement.—Velocity of the great American steam raft.—Approximate Table of tonnage, power, and consumption of fuel.—Mr. Morgan's assignment of due proportion of power to tonnage.—Dimensions of several Government steam packets.—Specification for construction of a 600 ton steam packet.—Diagrams of.—Separate water-tight iron bulkheads.—Mr. [illegible] method of Diagonal Planking. Iron vessels advantages of. Dimensions of the iron steam boat "Alburkah."—Construction and dimensions of the hull and machinery of the great steam ship "Great Britain."—Twin boats.—The great American steam raft.—[illegible] twin boats.—Gemmel's twin boats.

In proceeding to describe the form and construction of steam boats, we shall commence by noticing the points in which they most differ from sailing vessels. As the wind is generally more or less oblique to a vessel's course, or directed against the side of the vessel, and as the centre of effort of the sails in a ship is at a considerable height above the longitudinal axis of rotation, the wind acts with considerable leverage upon the sails and masts, to cause the ship to heel, or incline over to one side: to counteract this, and impart sufficient lateral stability, or stiffness, the breadth of sailing vessels requires to bear a greater proportion to the length than is necessary in steam vessels: the whole of the impelling force in the latter being exerted in the line of the vessel's course. Sailing vessels likewise require to be of greater comparative depth than steamers, to prevent their being driven laterally out of their course, (or to leeward, as it is termed,) when the wind is contrary; steamers being capable of proceeding directly head to wind, the point to be chiefly attended to is, that the form of the hull be such as to oppose the least resistance to its direct progress, and as the resistance depends chiefly upon the area of the immersed transverse section, their breadth and depth are generally considerably less than that of sailing vessels of the same tonnage, and the requisite capacity is obtained by a proportionate increase of length; thus, whilst in sailing vessels the breadth is rarely less than one-fourth of the length, in steam vessels it is frequently only one-seventh. Other advantages likewise result from this change in the proportions: steam vessels being employed chiefly as coasters, their light draught of water enables them to enter harbours which would otherwise be inaccessible to them. Their increased length also assists in preserving their parallelism, upon which their velocity greatly depends; and, as they do not pitch so suddenly nor so deeply in heavy seas, they hold their way better and the hull and machinery are less strained. Their increased length likewise affords greater accommodation for passengers, which is a very great advantage.

Resistance of Floating Bodies.—The question as to the best form for vessels is one which has long excited much attention in this and foreign countries. Many attempts have been made to determine, both by mathematical deduction and by experiments, the amount of the resistance of water to bodies of different forms, and the form of least resistance. But, since the application of steam to the purpose of navigation, the question becomes still more interesting, as, from the great expense of steam compared with wind, as a propelling power

nd the space occupied by the machinery, which tends greatly to e that can be allotted for fuel, and, consequently, the time which keep at sea, it becomes of the utmost importance to economise y reducing the resistance as far as possible. The question also rer approaches to accuracy in the solution in the case of steamers of sailing vessels, as experiments may be conducted so as to re to practice in the former case, than in the latter. The pro- of steam is likewise more direct than that of wind, and its force t and easily computed than that of the wind, which is constantly cannot be accurately estimated.

Experiments.—The most extensive sets of experiments upon the fluids to floating bodies, are those instituted in Sweden, under and at the expense, of the Society of Iron Masters of Stockholm, iments which were commenced in this country by the Society for ent of Naval Architecture, but which were subsequently carried the late Colonel Beaufoy, who devoted upwards of twelve years to nts, and to the calculations founded thereon, and expended several pounds in the prosecution of his researches. The results of his since his death, been given to the world by his son, H. Beaufoy, beth; who published the experiments in a thick extra quarto with a zeal in the cause of science, and a generosity, congenial er's, has printed 1,500 copies "*for the honour of gratuitous dis-*

contains most laborious investigations of the resistance of water great diversity of forms, and at greatly varying velocities; un- owever, the conditions exclude circumstances which materially result in all practical cases, and the conclusions, therefore, must rather as abstract truths, than as pointing out the results to be actice, unless modified by allowances for the actual circumstances

's Experiments.—In order to render the deductions of theory nt with the results obtained in practice, J. S. Russell, Esq., of nducted a series of experiments in the years 1834 and 1835, h and Clyde canal, under circumstances more analogous to the l practice than those of previous experimenters. He has since ount of these experiments in Vol. XIV. of the Transactions of ety of Edinburgh, of which we shall avail ourselves for a few e account is highly interesting, and likely to prove of great ty; Mr. Russell having ascertained the existence of certain phe- before adverted to, as well as the laws which regulate them; reat light on many intricate and perplexing points, and go far to e discrepancies which most accounts of extensive series of expe- it.

l observes, that the law which connects the resistance of the fluid nd power of the velocity, agrees very nearly with the motion of e wholly immersed, and with the motion of floating bodies that velocities, and are placed in certain circumstances; but it is us in its direct application to the motion of floating bodies at ies and under different circumstances. In every large collection , examples are to be met, where the resistance, instead of follow- the squares of the velocities directly, has been found to vary, very different power of the velocities, from the first to the fourth also in the inverse ratio of some of these powers. Two very ations of this are given in the following experiments by Mr. Russell; ng an increase of resistance, corresponding with a very high elocity, and the other exhibiting a decrease of resistance, with an locity greater than the former. They were made October 18, oating body weighing 12,579 lbs. :—

EXAMPLE I.

	Space described.	Time.	Velocity in feet per Second.	Resistance in lbs.
Experiment 1.	1,000 ft.	117·5	8·51	233
„ 2.	1,000 „	93·5	10·69	425

EXAMPLE II.

Experiment 3.	2,640 ft.	302·	8·76	261
„ 4.	500 „	35·	14·28	251

In the first two experiments it will be seen that the resistance increases in a greater ratio than the squares of the velocities, by nearly 15 per cent; while in the last two, in which the velocity increases from 8.76 to 14.28, the resistance actually becomes less, amounting to scarcely $\frac{1}{3}$ of what the law of the squares of the velocities would indicate.

The result of Mr. Russell's investigations appears to establish the following conclusions:—

That the resistance does not follow the ratio of the squares of the velocities; except in those cases where the velocity is low, and the depth of the fluid considerable. That the increments are greater than those due to the squares of the velocities, as the velocity approaches a certain quantity, which is determined by the depth of the fluid. That at this point the resistance attains a first maximum; and that here, by certain elements of the form of the body, and of the dimensions of the fluid, they may become infinite. That immediately after this, there occurs a point of minimum, where the resistance becomes much less than that due to the square of the velocity; after which it continues to receive increments of which the ratio is less than that due to the square of the velocity. That according to the law of progression which has been established, the resistance will reach a second point of maximum when a velocity shall be obtained of 29 miles per hour, after which it will be rapidly diminished with every increase of velocity.

These singular deviations of the law of resistance from a uniformly progressive ratio arise principally from two causes, but slightly (if at all) adverted to by former experimenters. The first of these is an *emersion* of the floating body from the fluid, due to the velocity of the motion of the body, and by which the dynamic immersion is rendered less than the statical immersion of the body in the fluid. The second is the generation of waves by the floating body in the direction of its motion, which affect the form and surface of the fluid, the position of the floating body, and of the resistance. The velocity of these waves (which Mr. Russell calls *the wave*, or the *solitary wave of progression*) depends neither upon the form of the floating body, nor the velocity of its motion, but solely upon the depth of the fluid.

The first of these phenomena had been slightly noticed by some previous observers, but the fact was questioned by many writers. Mr. Russell, however, has established the fact experimentally, and has laid down the theory by which it is to be accounted for. To ascertain the fact of emersion, the following experiments were made. A slight skiff was fitted with 12 glass tubes, accurately graduated, which passed through holes in the bottom of the vessel, and were open at both ends, so as to allow the water to rise within the tubes to the level of the water outside the boat. The boat thus fitted was drawn along the canal at different velocities, and the height at which the water stood in the tubes was carefully noted by an observer seated in the boat. The immersion of the boat when at rest being 2.7 inches, the dynamic immersions were as under:—

MILES PER HOUR.

Velocities.	0	3	4	5.16	6.43	7.
Dynamic Immersions.	2.7	2.6	2.5	2.2	1.9	1.8

thus clearly established the fact by experiment, Mr. Russell gives ng proposition in explanation of it, viz., that the pressure downwards d, by a body in motion at a given velocity, is diminished by a quantity pressure of a column of the fluid, having the height due to the the motion. The form of the floating body is no element in the emersion, the law being a general one, and having for its foundation principle, that gravity acting on a solid body during a given unit of nstant quantity, and that the displacement of the fluid by the weight y, being a quantity that increases both with the velocity and with y of that displacement, must ultimately be equal in quantity, as it is direction, to the pressure of the solid downwards by gravity. When, he depth of the fluid is small, the results will be modified by the wave, elements of resistance.

ard to the second and chief cause by which the resistance is in- he *wave*—Mr. Russell concludes, from his investigations, that the of the equilibrium amongst the particles of the fluid which has been y the motion of a floating body, is effected not so much by the of currents in the fluid, as has been hitherto generally assumed, as ation of waves, which form elevations in front of the moving body. travel to a great distance, with a velocity which is nearly uniform, depends solely upon the depth of the fluid; and in channels of section does not differ sensibly from that which is acquired by a y falling freely by gravity, through a space equal to half the depth of In a channel 5.5 feet deep, the velocity of the wave is about 8 miles

tance will chiefly depend upon the relative velocities of the wave vessel; the resistance increases rapidly as the velocity of the vessel that of the wave.

e vessel moves slower than the wave, the elements of increased re:—

ased immersion of the bow in the anterior wave.

ation of the longitudinal axis of the floating body, so as to change the displacing body.

ased vertical section opposed to resistance—the sine of the inclination ased velocity of the lateral current.

wing table shows the rapid increase of resistance in approaching the the wave. It is extracted from the experiments of 1838.

EXPERIMENT I.		EXPERIMENT II.	
iles per Hour.	Resis. lbs.	Miles per Hour.	Resis. lbs.
5.05	52.25	5.05	95
5.45	78.5	6.19	152
6.49	111.	6.49	312
7.57	255.	6.81	356
7.568	330.	7.	392
elocity of Wave, 8 Miles.		Velocity of Wave, 8 Miles.	

be supposed that the vessel had created a wave by its motion, and ossible to lift the vessel entirely out of the water, and place its e top of the wave, the stem being anterior to the wave, and its stern d suppose the vessel to be of such form as to remain in a state of on the surface of the fluid having the form of the wave, and that of the vessel be such as to keep it in the same relative position to e following results would be obtained:—

essel would recover its horizontal position, and would present the ast cross section of resistance.

2.—The immersion of the vessel being increased by the height of the crest of the wave around its centre of gravity, the head and stern displacements would be diminished (the total immersion being a constant quantity) by the amount of excess of central displacement.

3.—The velocity of the vessel being now increased beyond that of the wave, the waves of displaced fluid continually falling behind the points where they were raised, would form a series of great central waves, bearing the vessel on their summit.

When the velocity is greater than the wave, it might be expected that the wave would be left behind; but, in this case, it should be observed that a new wave is formed at every instant by the motion of the vessel through the water, whatever be its velocity; for the displaced fluid thrown aside at the bow generates a series of waves, which move with a less velocity than the vessel, and fall back behind the bow.

It is always found that the commotion produced in the fluid at velocities less than the wave is greater than at velocities exceeding that of the wave. The stem of the vessel in the latter case enters water which is perfectly smooth and undisturbed, because no wave has previously passed before the vessel to produce any anterior derangement.

It is to the diminished anterior section of displacement produced by raising a vessel with a sudden impulse to the summit of the progressive wave, that a very great improvement recently introduced into canal transport owes its existence. The isolated fact was discovered accidentally on the Glasgow and Ardrossan canal, which is a canal of small dimensions. A spirited horse, in the boat of Mr. William Houston, took fright, and ran off, dragging the boat with it, and it was then observed, to Mr. Houston's astonishment, that the foaming stern surge, which used to devastate the banks, had ceased; and the vessel was carried on through water comparatively smooth, with a diminished resistance. Mr. Houston, perceiving the mercantile value of this fact, devoted himself to introducing on that canal vessels moving with this high velocity. The result of this improvement has been to bring from the conveyance of passengers at a high velocity a large increase of revenue to the canal proprietors. The passengers and luggage are conveyed in light boats about 60 feet long, and six feet wide, made of thin sheet iron, and drawn by a pair of horses. The boat starts at a slow velocity behind the wave, and at a given signal, it is, by a sudden jerk of the horses, drawn up on the top of a wave, where it moves with diminished resistance, at the rate of 7, 8, or 9 miles per hour.

It appears, from the experiments of 1835, that a vessel has conveyed on a canal given weights with the following forces:—

Moving Force.	Weight Moved.	Velocity.
71.5 lbs.	19.222 lbs.	4 Miles per Hour.
86. ,,	19.222 ,,	4.5 ,,
112. ,,	19.222 ,,	5.2 ,,
246. ,,	8022 ,,	11.3 ,,
264. ,,	9262 ,,	13.6 ,,
331. ,,	10.262 ,,	15.1 ,,

In these experiments the vessel which experienced the least resistance was one designed by Mr. Russell, and to which he gave the name of *The Wave*.

This vessel was of very peculiar form, which suggested itself to Mr. Russell as a form of least resistance, and which even surpassed the expectations he had formed of the facility of her motion. The lines of entrance are parabolic tangent arcs, having a point of contrary flexure between the maximum transverse section and the stem. The run is formed of elliptical arches, and is by no means so fine as runs usually are. Mr. Russell was led to devise this form from an opinion, confirmed by long observations, that the maximum resistance

to a vessel of ordinary form is experienced in the immediate vicinity of the stem; that the water there is thrown aside with a velocity much greater than is requisite to remove the particles from the space to be passed over by the succeeding points of the bow. This head of water at the bow, instead of being merely thrown aside, is also thrown upwards and forwards, so as very much to increase the resistance beyond what appears necessary for the transit of the vessel. It occurred to him, that a form might, perhaps, be obtained which would not, at any given velocity, raise a head of water above the level, but merely give to the particles displaced the minimum of lateral motion required to permit the transit of the vessel. From his investigations he obtained a curve which appeared to him to be a curve of least resistance, and the vessel named *The Wave* was built conformably thereto; and the truth of his theory, being tested by experiment, was fully confirmed. This vessel, when deeply laden, and moving with a velocity of seventeen miles an hour, causes no spray, foam, surge, nor head-water at the bow, but the water is parted smoothly and evenly asunder, and quietly unites after the passage of the vessel; adhesion, alone, to the vessel drags forward a film of adjacent fluid; all else remains quiet and smooth.

The form of *The Wave* has been followed, as nearly as circumstances would admit, in some steamers recently constructed, and the results have been highly satisfactory.

Sir J. Robison's Experiments.—Prior to the experiments of Mr. Russell, J. Robison, Esq., afterwards Sir J. Robison, had instituted a series of experiments on the Forth and Clyde canal, with the view of ascertaining the best form of canal boats. Of these experiments (to which those of Mr. Russell may be considered as a sequel, as they were, we believe, undertaken at the suggestion, and made chiefly at the expense, of Mr. Robison) he has furnished an interesting account, in a communication to the Society of Arts, which appeared in the Transactions of the Society for 1833, from which we make the following extract:—

"Four models were prepared of the following dimensions—

		Ft.	In.		Ft.		Ft.	In.	
No. 1	was	8	3	Long,	2	Wide, and	1	0	Deep
" 2	"	8	3	"	2	"	1	6	"
" 3	"	8	3	"	2	"	1	6	"
" 4	"	9	1	each part	1	foot wide	1	0	"

And the weight of each $187\frac{1}{2}$ lbs.

"No. 1 was quite flat on the floor, rounded at the bilges, and perpendicular in the sides at the midships section, but with a fine entrance and run.

"No. 2 was made in the proportions of an ordinary coasting trader.

"No. 3 in the proportions of a sharp built schooner.

"No. 4 was a twin-boat, similar in its dimensions to No. 1, only that the breadth of each portion was half of the other breadth: the depth was the same.

"The weight of all the models being alike, their displacement of water was equal, although their draft or depth of immersion was necessarily different.

"The usual way of trying the resistance of floating bodies is by drawing them across a dock or basin by a cord, running over delicately hung pullies, on a high mast, and with certain weights attached; the time is accurately noted which each form requires to move through a certain space, and the comparative resistances are calculated from these elements. This method presents many difficulties and disadvantages. I was enabled, however, by a suggestion from an ingenious friend (Mr. Oldham, of the Bank of Ireland), to adopt a much more summary and satisfactory way of determining the comparative resistance of the different models; and, as it was the comparative resistance alone which required investigation, I had no occasion to go through the more tedious process of trying the resistance only, and of incurring the risk of error

from mistake in reading off the indications of the dynamometer. I prepared, accordingly, a spar, or yoke, sixteen feet eight inches long, which was divided into 100 parts of two inches each: a small eye-bolt was fixed at each extremity, and a shifting hasp was fitted to the middle part. With this yoke all the experiments were made, by the two following processes:—First, a model was attached, by a slender tow-line, to each eye-bolt, and the hasp was fixed exactly in the middle of the yoke, and linked to an outrigger on the steam vessel, which was then set in motion at the required speed. If it was found that one of the models preceded the other in consequence of its offering less resistance, the hasp was shifted along the spar towards the sluggish one, until the resistances were balanced, and the two models ran abreast of one another. The relative lengths of the arms of the yoke then gave an inverse measure of the comparative resistances of the models at that rate of speed; this being noted down, the hasp was brought again to the middle of the yoke, and the model which showed least resistance was, by degrees, loaded with weights, until it again exactly balanced the other, and swam abreast of it; the amount of the added weights being likewise noted, afforded a second measure of the difference of the resistance of the two models.

"Each of these forms of the experiment was gone through with different pairs of the models, and was frequently repeated through long spaces of the canal, as it was found that various circumstances interfered to render the resistances inconstant, such as approaching nearer to the one or other side of the canal, passing a loaded vessel, or making a turn round a projecting part of the bank. It was first attempted to conduct the experiments by towing the models astern; but it was immediately found that the ripple of the wake of the steamer disturbed the uniformity of the resistance of the models. Various modifications were then tried, with more satisfactory results, and finally the arrangement was made as follows:—A spar like a bowsprit, about twenty feet in length, was run out a little above the level of the water from the bow of the steamer, the hasp of the yoke being attached by a link to the point of the spar, the models were in this way kept ahead of the steamer in smooth water, and were altogether undisturbed by any ripple or wave."

The accompanying tables contain the results of these trials, from which the important inference may be drawn, that there is no form which will present a minimum resistance in all circumstances; and that the form which is easiest drawn through the canal at a low velocity, does not possess the same advantages at a higher rate of speed.

By looking into the table A, experiment 1st, we see that, although the resistance of No. 1 be to that of No. 2 as 13 to 12 when the velocity is three miles per hour, yet, when the speed is increased to six miles, the advantage which No. 2 had over the flatter vessel entirely disappears.

Again, in Table B, we see that in one experiment No. 2 carries two-ninths more weight than No. 1 with equal resistance when the velocity is three miles per hour; but that, when the rate is raised to six miles, the loads required to be the same in both, in order to equalize the resistance.

It appears, from numerous experiments made at intermediate speeds, that this change in the relative resistance is progressive: there is reason, therefore, to conclude, that if circumstances had admitted of carrying on the experiments at a higher velocity than six miles per hour, the flatter formed vessel would have attained a superiority over the sharper ones. This conclusion is corroborated by the fact that the swiftest going steam vessels which have been built in this country, are those which are nearly quite flat in the floor for a great proportion of their whole length.

The first practical inference which may be drawn from these experiments is, that all vessels which are intended to be tracked, or impelled by machinery through canals, at low velocities, should be built as sharp in their bottoms as circumstances will admit of, although this must necessarily increase their draught of water; the second inference is, that whenever vessels are intended to move in canals with a higher rate of speed than six miles per hour, the general form of the bottom should be quite flat.

EXPERIMENTS WITH EQUAL LOADS.

(In favour of No. 1.)

Models tried.		United Weights of Vessel and Load.	Divisions in the Arms of Yoke when at 3 Miles per Hour.		Difference.	Divisions in the Arms of Yoke when at 6 miles per hour.		Difference.
Flat Vessel & Coaster.	No. 1 and 2	192 lbs. each.	No. 1, 48	No. 2, 52	4 Divisions = $\frac{1}{12}$	No. 1, 50	No. 2, 50	None.
	ditto	256 „	„ 46	„ 54	8 „ = $\frac{1}{6}$	„ 50	„ 50	None.
	ditto	320 „	„ 47	„ 53	6 „ = $\frac{1}{8}$	„ $49\frac{1}{2}$	„ $50\frac{1}{2}$	1 Division = $\frac{2}{99}$
	ditto	392 „	„ 45	„ 55	10 „ = $\frac{1}{5}$	„ 49	„ 51	2 „ = $\frac{1}{24}$
Flat Vessel & Schooner.	No. 1 and 3	192 „	No. 1, 45	No. 3, 55	10 „ = $\frac{1}{5}$	No. 1, 50	No. 3, 50	None.
	ditto	256 „	„ 43	„ 57	14 „ = $\frac{1}{3}$	„ 50	„ 50	None.
	ditto	320 „	„ 44	„ 56	12 „ = $\frac{1}{4}$	Uncertain.		
	ditto	392 „	„ 45	„ 55	10 „ = $\frac{1}{5}$	No. 1, 49	No. 3, 51	2 Divisions = $\frac{1}{24}$
Flat Vessel & Twin ditto.	No. 1 and 4	256 „	No. 1, 50	No. 4, 50	None.	Uncertain.		
	ditto	320 „	„ 53	„ 47	6 Divisions = $\frac{1}{8}$	ditto		
	ditto	392 „	„ 52	„ 48	4 „ = $\frac{1}{12}$	ditto		
	ditto							

TABLE B.

Experiments with equal arms of the Yoke at 3 miles per hour.

Models Compared.		Depth of Immersion in Inches.	Weight of Vessels with their Loads.	Difference.	
Flat Vessel.	No. 1	4.91	256 lbs.	32 lbs.	No. 2 carries $\frac{1}{9}$ more than N…
Coaster.	No. 2	8.5	288 "		
	No. 1	6.083	320 "	72 lbs.	No. 2 carries $\frac{2}{11}$ more than N…
	No. 2	10.083	392 "		
Flat Vessel.	No. 1	4.17	192 "	42 lbs.	No. 3 carries $\frac{2}{11}$ more than N…
Schooner.	No. 3	8.41	234 "		
	No. 1	5.75	320 "	42 lbs.	No. 3 carries $\frac{2}{15}$ more than N…
	No. 3	10.25	362 "		
Flat Vessel.	No. 1	4.17	256 "	0	No difference at this rate of sp…
Twin Vessel.	No. 4	4.	256 "		

N.B. The depth of immersion entered above is that observed when the ve… were at rest, and which did not appear to alter when in motion.

TABLE C.

Experiments with equal arms of the Yoke at 6 miles per hour.

Models Compared.		Depth of Immersion in Inches.	Weight of Vessels with their Loads.	Difference.	
Flat Vessel.	No. 1	4 $\frac{2}{12}$	192 lbs.		The draught of water noted … the column of immersions … that observed when the mod… were at rest previous to … commencement of each exp… ment; the actual immers… during the experiment … considerably less, especially … the flatter vessels; but th… were no means of ascertain… it precisely.
Coaster.	No. 2	6 $\frac{4}{12}$	192 "		
	No. 1	4 $\frac{11}{12}$	256 "		
	No. 2	8 $\frac{1}{12}$	256 "		
Flat Vessel.	No. 1	4 $\frac{2}{12}$	192 "		
Schooner.	No. 3	7 $\frac{2}{12}$	192 "		
	No. 1	4 $\frac{11}{12}$	256 "		
	No. 3	9 $\frac{2}{12}$	256 "		
Flat Vessel.	No. 1	5 $\frac{8}{12}$	320 "		
Twin Boat.	No. 4	5 $\frac{7}{12}$	320 "		

Proportion of Power to Size of Vessels.—The proportion which the power of engines should bear to the size of the vessel depends greatly upon the nature of the service for which the vessels are intended. Post-office packets, or vessels depending chiefly upon passengers, for instance, require and will admit of engines of larger power than vessels employed principally in the transport of goods, in which latter, less space can be afforded for the machinery and fuel, on account of the room required for the cargo. The proportional power must likewise depend partly upon the size of the vessel, for, as the resistance to a vessel's progress depends principally upon the area of the transverse section immersed, which area does not increase in the same proportion as the capacity of the vessel, larger vessels require less power in proportion than smaller ones. For instance, if two vessels be built upon the same model, but one of them of double the tonnage of the other, their proportional linear dimensions will be as 126 to 100, and their sectional areas as 158 to 100; therefore, to obtain the same velocity, the power will only require to be increased in the same ratio as the sectional area, or as 158 to 100; if the power in each vessel were in the direct ratio of the tonnage, or as 200 to 100, the ratio of the power to their sectional areas would be 200 to 158.

Viewed solely as a question of economy without regard to speed, it might at first sight be concluded that vessels must be worked at less cost with engines of small power than with large ones, for the resistance to a vessel's motion through the water increases more rapidly than in the ratio of the velocities. The resistance of a fluid to a body moving therein is generally stated to be as the square of the velocities; a double speed occasioning a fourfold resistance, so that if it required 100 horse power to propel a vessel at the rate of 5 miles an hour, it would require 400 horse power to produce a speed of 10 miles per hour. This ratio, however, applies only to the resistance of the particles of the fluid in a quiescent state, and also assumes that the area of the immersed section is the same at all velocities, but the progress of vessels is influenced by various other causes, besides the inertia of the water, as tides or currents, and the force of the wind and sea; resistance from these causes has little or no relation to the speed of the vessels, and will require a certain amount of power to overcome them, independent of that which is required to overcome the inertia of the water; and the greater the amount of the resistance from the former causes in proportion to that from the latter, the more will the result vary from the theoretical calculation. In some circumstances, therefore, the consumption of fuel may be even less in going a given distance with large engines than with small ones. Let us suppose that a vessel, fitted with engines of 100 horse power, will go 10 miles an hour in still water, and that another vessel with 50 horse power will in the same circumstances go 7 miles per hour; if these vessels have to stem a current of 4½ miles per hour, the effective speed of the first will be reduced to 5½ miles per hour, and that of the second to 2½ miles per hour; the former, therefore, would perform a distance of 100 miles in 18 hours, and the latter in 40 hours; and as the large engine would only consume twice as much fuel per hour as the small one, it would consume in 18 hours only as much fuel as the smaller would in 36 hours, and, consequently, the consumption would be as 36 to 40 in favour of the larger power. But independently of these casual resistances, the resistance from the inertia of the water is found not to increase as rapidly as the square of the velocity; from the circumstance that with a considerable increase of speed, the vessel has a tendency to rise from the water, or diminish her draught, so that the area of the immersed section becomes less, and the head wave also decreases. This circumstance may appear paradoxical, but it seems to be well ascertained by a careful observation of facts, both in this country and in America. The *Great American Steam Raft* is stated frequently to have attained a speed of 20 miles per hour, at which time her draught of water was 7 inches less than when still, and there was no head wave. The same facts have been elicited by numerous experiments in this country with boats upon canals and drawn by horses, and will be found to be noticed in the experiments of Sir J. Robinson and Mr. Russell, of which we have already given extracts.

From the foregoing considerations, which have been confirmed by experience, the proportion of the power to the tonnage in seagoing steamers has been gradually augmented; vessels recently built having generally engines of greater power than old vessels of the same tonnage. Small engines are also frequently removed from vessels, and others of greater power substituted for them, with decided advantage, not only as to speed, but also with respect to the economy of fuel; their consumption per voyage, or for the same distance, being less with the large engines than it had previously been with the smaller ones.

The measured tonnage of a vessel, however, affords rather an uncertain criterion of the comparative amount of power required, as, from the improper mode of estimating the sizes of vessels or measuring them still in practice, a small vessel may be made to measure a great deal, and a large vessel may be made to measure very little. In all steamers, the vessel displaces considerably more than the measured tonnage.

Mr. Morgan, who has had considerable experience in this matter, and who has paid great attention to this subject, in his evidence before the committee on steam communication with India, assumes the displacement of the vessel as a better standard, and for vessels going long sea voyages deems 1 horse power to 4 or $4\frac{1}{2}$ tons displacement a good proportion. He, however, advocates building the vessels of a sharper form than is generally done, so as to make the measurement and displacement nearly accord. We select from this gentleman's evidence the dimensions of some of the government steam packets, which will show the great discrepancy between the measurement and displacement.

The Flamer.—156 feet in length; 26 feet 8 inches beam; depth, 15 feet 3 inches; measured tonnage, 496 $\frac{42}{94}$ tons; nominal power, 120 horses.

	TONS.		
Her hull weighs	300	Tonnage, 590.	With this displacement, she draws 11 feet 5 inches aft, and 10 feet 10 inches forward, in sea-water, and the area of her midship section, immersed, is about 225 feet.
Her engines	120		
Provisions, stores, masts, anchors, &c.	30		
Coals	140		

Her cylinders are 42 inches in diameter, with a 4-feet stroke. Her wheels (Morgan's) are 18 feet in diameter, and 5 feet 6 inches wide.

When the vessel is deep, her wheels revolve	from 14 to 20 times per minute in heavy weather, and 25 times in light weather.
When the vessel is light, their speed increases	from 18 to 22 revolutions per minute in heavy weather, and from 26 to $26\frac{1}{2}$ revolutions in light weather.

The Columbia.—129 feet in length; 24 feet 6 inches beam; and 15 feet in depth; measured tonnage, 360 tons; nominal power, 100 horses.

	TONS.		
Her hull weighs	250	Tons, 494.	With this displacement, she draws 12 feet 6 inches aft, 11 feet 4 inches forward, in sea-water, and the area of her midship section, immersed, is about 213 feet.
Her engines	104		
Provisions, stores, masts, anchors, &c.	30		
Coals	110		

Her cylinders are 39 inches in diameter, with a 3 feet 6 inch stroke. Her wheels are 17 feet in diameter, and 5 feet 2 inches wide.

When the vessel is deep, her wheels revolve	from 14 to 20 times per minute in heavy weather, and from 20 to 25 times in light weather.
When the vessel is light, their speed increases	from 16 to 22 times per minute in heavy weather, and from $26\frac{1}{2}$ to 28 per minute in light weather.

The Firefly.—150 feet in length; 28 feet 2 inches beam; depth, 17 feet; measured tonnage, 360; nominal power, 110 horses.

	TONS.		
Her hull weighs	330	Tons, 715.	With this displacement, she draws 12 feet aft, and 11 feet 4 inches forward, in sea-water, and the area of her midship section, immersed, is about 270 feet.
Her engines	150		
Provisions, stores, masts, anchors, &c.	35		
Coals	200		

Her cylinders are 44 inches in diameter, with a 4 feet 6 inch stroke. Her wheels are 18 feet in diameter, and 9 feet 2 inches wide.

When the vessel is deep, her wheels revolve	from 17 to 19 times per minute in smooth water, and from 6 to 12 per minute in heavy weather.
When the vessel is light, their speed increases	from 20 to 21 revolutions per minute in fine weather, and from 8 to 14 in heavy weather.

The displacement certainly offers a better standard than the measured tonnage for estimating the power required in steam vessels; but we think the area of the immersed transverse section is the best basis of calculation; for, upon this the resistance chiefly depends. Thus, a steam-boat which has been lengthened generally sails faster with the same engines than before; because, although her measured tonnage is thereby increased, yet, from drawing less water, the area of the immersed transverse section is diminished.

In the three examples just given, the sectional area is to the horse power as follows:

Flamer	1·9	feet area to 1 horse-power.
Columbia	2·13	„ „ „
Firefly	1·6	„ „ „

A fair proportion seems to be from $1\frac{1}{2}$ foot to 2 feet section per horse-power, according to the nature of the service for which the vessel is intended.

Construction.—In regard to the mode of constructing and fastening steamers, much diversity of practice exists; but, generally speaking, strength and durability are not sufficiently studied; and, although improvements are taking place in this respect, much remains to be done. In order to give a general notion of this branch of the subject, we shall insert some extracts from the specification of a steamer of 600 tons burthen, built for the City of Dublin Steam Packet Company. It was furnished by C. W. Williams, Esq., the managing director of the Company; and the improvements recommended are those which, from the long experience of the Company, will admit of no doubt of their efficacy.

Mr. Williams recommends generally—

1. That the hull be divided into at least five separate compartments, by four iron-plate water-tight bulkheads, or partitions, so as to confine the water or fire to the compartments in which either may have originated.

2. The substituting of copper or composition bolts, with nuts and screws, in the fastening of the planking, and other parts, in place of tree-nails, the use of which should be entirely exploded.

3. The addition of hanging iron knees, properly constructed, with stays under the main and middle deck beams, wrought and fitted with care, according to prepared drawings; also, a continuous connexion of iron staple knees, by which the entire series of deck beams are firmly bound together, and to the sides of the vessel.

4. The adoption of an improved garboard strake, cut from a solid baulk, and fitted to the rabbet of the keel. Mr. Lang has lately done much towards introducing this valuable improvement.

5. The attaching the sister kelsons and sleepers, on which the engines and boilers are placed, firmly to the bottom of the vessel, by a proper system of

bolts, passed through the flooring and bottom planking, and by lateral stayings; these sister kelsons passing the entire length of the vessel. This mode of strengthening a steamer is very little in use.

6. The introduction of powerful longitudinal wrought-iron stay-bolts, four at least, and from $1\frac{1}{2}$ to $2\frac{1}{2}$ inches diameter, running the entire length of the main-deck, and through all the main-deck beams, properly secured to each with washers and cotters on the fore and after side of each beam; so that each deck-beam be not only thus tied together, but that each shall bear its due proportion of any strain of the vessel endways in a heavy sea. These iron longitudinal bolt-stays have been introduced with great advantage into several steamers, which had previously worked considerably in a sea-way.

7. The introduction of an inner lining of sheet lead under the lining of sheet iron, and next to the skin of the vessel, to prevent the desiccation and charring of the timber bottom and sides, which the excessive heat and the decomposition of the fine powder of the coal in the neighbourhood of the engines and boilers frequently occasion. This under-sheeting of lead has been found an effectual remedy.

8. The use of iron in the various hatchways, ceilings, and scuttles, instead of timber, which latter weakens the deck of a vessel, whereas the former strengthens it.

9. The introduction of longitudinal cast-iron beams in lieu of wood, the entire length of the boiler hatchways, and to which is attached a wrought-iron deck-plate, the full size of the boiler hatchway. These iron beams secure that vulnerable part of the deck from contraction, sinking, or fire. The wood beams and deck usually adopted over the boilers contract instantly, and thus admit water to the top of the boiler.

10. The preparing the entire timbering, planking, decks, &c. on Kyan's or other anti-dry-rot principle, thus securing the greatest durability to the hull. This steeping process is effected in the builder's yard, and under the especial superintendence of a competent individual on the part of the owners.

Fig. 1

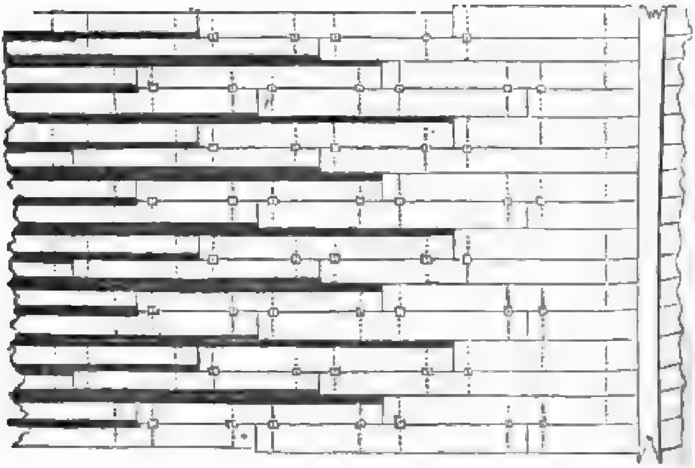
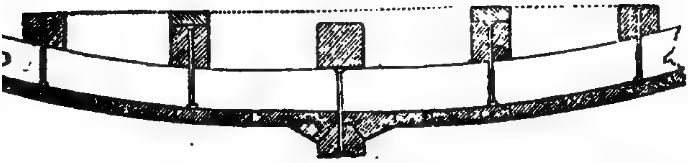


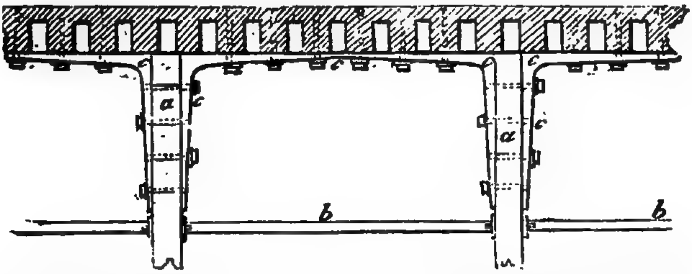
Fig. 1 exhibits a plan of the solid floor, timber, and futtocks, with cogues and bolts; the black parts denote spaces which are to be filled in solid, and the dotted lines denote the bolts.

Fig. 2 is a section of the keel and garboard strake with bolts.

Fig. 2.

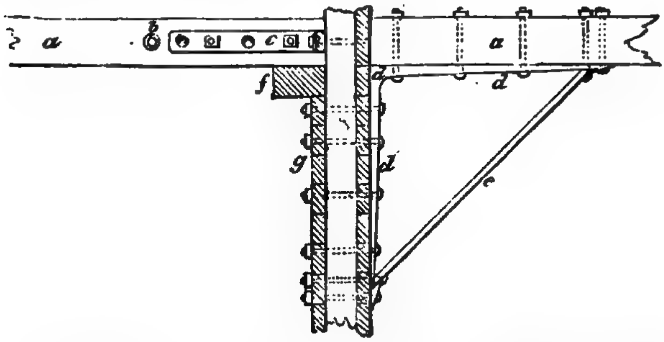


[T]he following engraving is a horizontal section of a portion of the frame at ɪ main deck, with staple knees, and longitudinal iron stay bolts.



ɪ *a* are the deck beams; *b b*, an iron stay bolt, $2\frac{1}{2}$ inches diameter, runɪg the whole length of the vessel; there are four of these bolts; they pass ough every beam, and are raised up on each side of the beam, and the beams ɪng laid close enough to support the decks, carlings are not required; *c c*, the rizontal staple knees, secured to the sides and beams with screw bolts and ꞌs.

ɪubjoined is shown a vertical section of the hanging knee and stay, which ports the outer end of the main deck beam.



ꞌ main deck beam; *b*, the longitudinal stay bolt; *c*, the staple knee; *d*, ɪg knee bolted by screw bolts to the side and to the main deck beam; onal stay to the knee; *f*, the shelf piece; *g*, the inner planking.

ion of Hull.—The subdivision of the hull into separate waterartments by means of plate iron bulkheads calls for particular ɪe following observations by Mr. Williams will show the importance ꞌovement, and an effectual method of carrying it into practice.

ualties to which ships (especially steam vessels) are liable arise, for rt, first from striking against or coming in forcible contact with h solid bodies as would injure the frame-work of the vessel; and,

secondly, from accidental collision with other vessels, by which some part of one, or both, becomes so damaged as to admit the water to such an extent as to overcome the power of the crew to pump it out.

"That any expedient shall be discovered which will prevent the irruption of the water to an extent beyond what may be within the power of men and pumps to expel, is hopeless. Even in the event of running on an anchor, or other body, which should break any part of the ship's bottom or side, or of a single plank starting, the extent of the injury would most likely be such as to render it impossible to keep the vessel afloat by human power. It occurred to me, that the only practicable expedient for preventing the sinking or actual submersion of the entire vessel would be by confining the effect of the injury sustained to that portion or section of the vessel in which the injury occurred; and this is the basis of the plan I am now to submit. The plan of dividing the vessel's hull into sections, each of which should be completely water-tight, has, we are told, been practised by the Chinese in their trade barges. This mode of giving security first occurred to me on building the iron steamer *Garryowen* (now plying on the Shannon at Limerick), and the trade barges which the Dublin Company's steamers tow on that river. Where the hull was of iron, as in the *Garryowen*, the introduction of iron plate bulkheads was easy and effective; and, independently of the great strength afforded by this internal and sectional bridging (as it may be called), these sections were as susceptible of being made water-tight as the hull itself.

"Experience has proved that it is impossible to make a timber partition or bulkhead water-tight, or, at least, that it should continue so. The heat of the vessel is sufficient to cause such a shrinking in a partition of timber planking as to render it wholly useless in preventing water from passing. Iron plate partitions, however, possess all the requisites for this effectual division of the vessel into so many water-tight compartments. Their introduction, then, into timber vessels appeared an important desideratum. The only parts where water could find its way from any one section when filled to another section not so filled, would be, not through the iron partitions, but at the sides and bottom of the vessel, where they come in connexion with the frame and planking of the vessel. The preventing the water from passing in this direction is effected by very simple means, viz. by making this part of the vessel solid, that is, without those rooms or spaces which intervene between the frames of the vessel; this solid framing should extend 18 inches before and abaft each partition. The mode of effecting this is familiar to all shipbuilders. The introduction of hair-felt between this solid framing and the planking on the outside and the ceiling on the inside completes the operation; the plate iron forming the partition having proper diagonal stays to give it strength, and being connected at the sides and bottom with angle iron, accurately fitted to the shape of the vessel, particularly in passing over the kelsons."

With regard to the number of these bulkheads, Mr. Williams is of opinion that four bulkheads, dividing the vessel into five compartments, afford the most eligible arrangement. The centre section will then be occupied by the engine, boiler, and coal bunkers. The section next to the centre will form the fore and after holds; or in the case of passenger vessels, the fore and after cabins; and the two remaining sections at the bow and stern need not be so high as the main deck, as the water never could rise within several feet of the same.

To prove the efficiency of these bulkheads, Mr. Williams tested the plan experimentally, under the inspection of the members of the British Association, in a new vessel, the *Royal Adelaide*. The vessel was first bored in the bow section, and the water allowed to flow freely in. When so filled that the water remained at the same height, outside and inside the section, it depressed the vessel at the bow six inches, and raised the stern about two inches. The water was then pumped out, and the adjoining section filled; this depressed the bow 12 inches without perceptibly raising the stern.

Iron Bulkheads.—Here, then, we have an effectual remedy against the casualties attending on a vessel coming into collision with another. Unless the

water break into the vessel in all the sections at the same time (which is almost impossible), there can be no danger of submersion. These bulkheads afford, also, a protection against fire. The circumstance of any part of an ordinary vessel taking fire is followed by the rapid spreading of it through all parts of the vessel. An instance of this calamity occurred recently to the steamer, the *Medway*, on the river Thames, where the only resource that remained to the numerous passengers was the confining themselves to that part of the deck most distant from the fire until the vessel was run on shore. These iron bulkheads, being air-tight, effectually prevent the introduction of any draught or current of air, so much to be dreaded. Again, in extinguishing the fire in the section in which it originated, the crew would be enabled to work in comparative security. The fire, being prevented spreading laterally, can only make progress upwards towards the deck, and which will be considerably retarded, if not altogether checked, by the absence of all current of air from either end of the vessel. Indeed, it is questionable whether the mere closing down the hatches over the section would not entirely extinguish it. These bulkheads have been adopted in many vessels belonging to the City of Dublin Company, and other parties have since followed their example, although the plan is far from being so extensively adopted as it deserves to be. With regard to the additional weight and expense, they are trifling in comparison with their importance and the security which they afford. Mr. Williams states that the bulkheads in the *Royal William* and *Athlone* cost £290 each vessel; and the additional timber in the solid framing must be trifling.

Mr. Lang's System.—The following plan of building steamers has been introduced with great success by Mr. O. Lang, of H. M. Dockyard, Woolwich.

Upon the keel being laid (say for a vessel of 300 tons), 1¼ inch oak plank is passed diagonally, at an angle of 45°, from one side under the keel up to the plank share on the other side. At the fore and after ends, from the rise of the floor, the planks cannot be passed under, and are rebated into the keel. The first planking is caulked and payed; then a second range of planking, 1¼ inch thick, at an angle of 45°, is laid on the first, with patent felt between, crossing the direction of the angle, and this second planking is again caulked and payed. Then the third row, 1½ inch thick, is put on longitudinally, with felt between, like the ordinary planking of a vessel, and caulked and payed ⅜ inch through; bolts are used, and clenched upon ruffs such as boatbuilders use. Bent timbers are then placed inside, at every four feet apart, with small floor timbers for carrying the sleepers. The following vessels, now running upon the Thames, are built upon this plan,—*Ruby, Gem, Diamond, Duchess of Kent, Topaz, Prince George, Fairy, Naiad, Ariel, and Nymph.*

Iron Vessels.—Owing to the many advantages attending the construction of vessels made entirely of wrought iron, excepting the decks, a decided preference is now given to them, and they are fast becoming almost universal. Amongst the numerous advantages may be mentioned,—

1. An iron vessel does not weigh half so much as a wooden one of similar dimensions; consequently draws much less water.

2. An iron vessel affords much more room for stowage, owing to the decreased thickness of its sides, those of the latter not exceeding four inches, including the angle iron ribs to which the plates are fastened; while those of a wooden vessel of the same dimensions are not less than twelve inches thick. Thus a wooden vessel, of 24 feet beam outside, would be only 22 feet inside; whilst an iron one would be 23 feet 4 in.; making a difference of 16 inches all round; which difference, in a vessel measuring 150 feet long, 24 feet beam, and 16 feet deep, affords room for the stowage of 80 tons more of cargo than the wooden vessel.

3. Owing to the diminished draught, or the necessity of displacing a less weight of water, an engine of equal power to that on board a wooden one will propel it much faster, or one of less power equally fast. In the latter case, there is effected a proportionate saving of fuel; in the former, a saving of both time and fuel.

4. Iron vessels are much cooler, owing to the metal being a rapid conductor of heat.

5. The air in the holds of iron vessels is much purer, not being contaminated with foul bilge-water, as is the case with wooden ones.

6. They are less liable to leak; and the leak, when made, more easily stopped, the fracture or hole being generally much smaller, and capable, usually, of being beaten back into its former position.

7. Iron vessels do not, like wood, become heavier by saturation.

8. Iron vessels are not subject to be affected by lightning, that fluid being conducted into the water by the metal.

9. Owing to the greater tenacity of the metal, iron vessels may be constructed of greater dimensions than wood.

The first iron steam vessel built for sea was the *Alburkah*, constructed by Mr. Laird to take part in the expedition to the Niger, conducted by Mr. Laird. Her dimensions were,—length, 70 feet; breadth, 13 feet; depth, 6 feet 6 in. The plates in her bottom were only $\frac{1}{4}$ inch thick, and those in the sides only an eighth. When launched, she drew but 9 inches of water; with her engines, boiler, and various fittings, about 3 feet 4 inches. Her weight, including the decks, was 15 tons. The engine, of 15 horse power, and boiler, added about 15 tons more.

The foregoing exhibits an example of one of the smallest iron vessels, and the following affords a magnificent specimen of the *largest* iron vessels hitherto constructed.

The *Great Britain*, having a tonnage of 3443, by the old measurement, was built at Bristol by the same Company which brought out the *Great Western*, the largest wooden steam vessel previously produced. The *Great Britain* was chiefly constructed under the direction and management of Mr. Thomas Guppy, with whom was connected Mr. Isamberd Brunel, as consulting engineer. The length of the keel of this noble vessel is 289 feet; total length, 322 feet. Her beam or breadth is 51 feet; depth, 32 feet 6 inches. Her draught of water when loaded, 16 feet. Displacement, 2984 tons. The ribs are of angle iron, 6 inches by $3\frac{1}{2}$, $\frac{1}{2}$ and $\frac{7}{16}$ thick. Distance of ribs from centre to centre amidships, 14 inches, increasing to 21 inches at the ends.

Ten iron sleepers run from the engine-room, (gradually diminishing in number to the fore end of the ship,) and under the boilers, the platform of which they support. In midships they are 3 feet 3 inches in depth, supported by angle irons in the form of inverted arches, a short distance from each other.

She has five water-tight partitions; stows 1200 tons of coal; has a space for 1000 tons of measurement goods. The engines weigh 340 tons, the boilers 200 tons, and they hold 200 tons of water.

The main shaft is 28 inches in diameter in the centre, and 24 inches in the bearings; in the rough, before it was turned, it weighed 16 tons: it was lightened by a hole of 10 inches diameter, bored throughout. A stream of cold water is caused to flow through this hole and the cranks while the engines are at work.

The screw shaft consists of one long, and two short, or coupling parts. The part next the engine is solid, 28 feet long, by 16 inches in diameter. The hollow intermediate shaft is 65 feet long, and 32 inches in diameter. The screw part is 25 feet 6 inches long, and 16 inches in diameter. The total length of this shaft is 130 feet, and weighs 38 tons. The screw has six arms, 15 feet 6 inches in diameter, and weighs 4 tons.

The main drum is 18 feet diameter, and drives 4 chains, weighing 7 tons. The screw shaft drum is 6 feet diameter, and the weight with the pull when working is equal to 85 tons on the bearings of the main shaft.

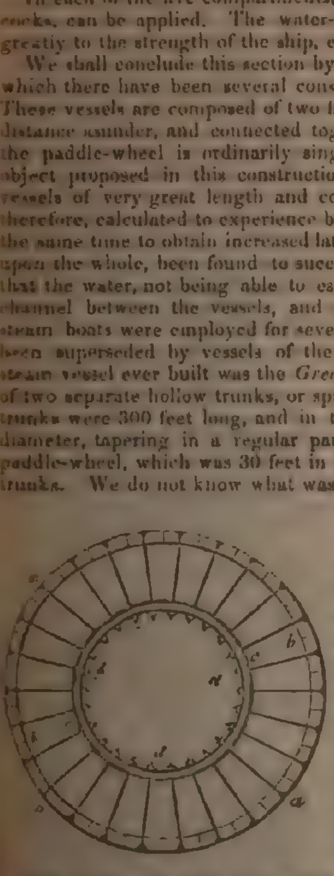
The steam cylinders are four in number, 88 inches in diameter, and with a stroke of 6 feet. The condensers are of wrought iron, 12 feet by 8, and 5 feet deep. Under the whole space occupied by the engines up to the top, the angle irons are doubled.

The upper main and saloon decks are of wood, the two cargo decks are of iron. The officers and seamen are all accommodated on two decks under the

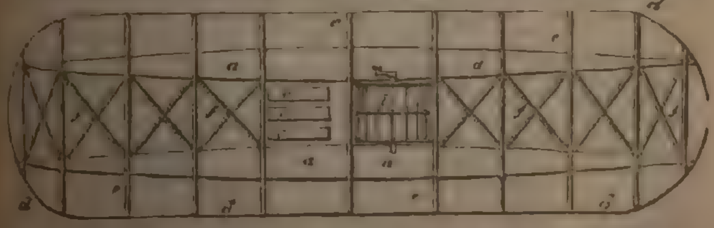
forecastle. She has six masts fitted with iron rigging. Five of the masts are hinged for lowering during contrary gales. She is provided with seven life-boats, capable of carrying 400 people. She is built with lapped joints in preference to flush, the former having been proved, to the satisfaction of the Company, to be one-fifth stronger than the latter mode.

In each of the five compartments, the engine pumps, by means of pipes and cocks, can be applied. The water-tight divisions of each compartment add greatly to the strength of the ship, either as struts or ties.

We shall conclude this section by a notice of what are called Twin Boats, of which there have been several constructed both in this country and America. These vessels are composed of two floating bodies placed side by side, but some distance asunder, and connected together by a deck extending over both, and the paddle-wheel is ordinarily single, and placed in the middle. The chief object proposed in this construction is to obtain great speed by employing vessels of very great length and comparatively small transverse section, and, therefore, calculated to experience but little resistance from the water, and at the same time to obtain increased lateral stability. The plan, however, has not, upon the whole, been found to succeed: one objection we understand to be, that the water, not being able to escape laterally, accumulates in the space or channel between the vessels, and materially increases the resistance. Twin steam boats were employed for several years on the Tay ferries, but have since been superseded by vessels of the ordinary construction. The largest twin steam vessel ever built was the *Great American Steam Raft*, which was formed of two separate hollow trunks, or spindles, with a deck laid over them. These trunks were 300 feet long, and in the centre, or thickest part, were 8 feet in diameter, tapering in a regular parabolic curve to a point at each end. The paddle-wheel, which was 30 feet in diameter, worked in the space between the trunks. We do not know what was the power of her engines. The marginal figure is a cross section of one of the trunks. *a a a* are the staves, 26 in number, and 3½ inches thick, to each of which is attached an iron bolt, *b b*, 26 inches long, passing through the staves, and countersunk on the outside of them. These bolts pass through an iron ring, *c*, on the inside of which they are screwed up by nuts, *d d* so that the staves are brought into very close contact; sufficient room is left in the centre for a man to enter and pass fore and aft, and turn the nuts, if necessary.

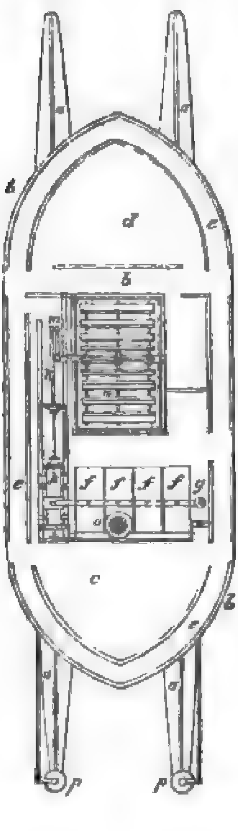


The annexed figure shows the plan of the beams connecting these two spindles, or trunks, upon which the decks are built: *a a* the trunks or spindles; *b* the paddle-wheel; *c c c* the boiler; *d d* the beams which connect it with the outside guard; *e e, f f*, the braces. This vessel was built at New York; was destined to ply between that city and Troy,

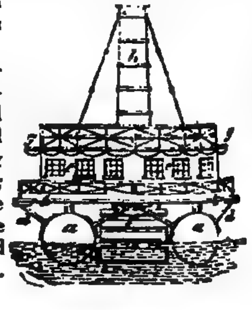


distant about 160 miles up the Hudson. It is said, that on her first trip she ran [illegible] miles in 61 minutes, and that her average speed was about 20 miles per

hour; the greatest *authenticated* speed *at sea* was, however, only 14 miles per hour. At anchor her draught of water was 24 inches, but when running at her greatest speed it was stated to have decreased to 17 inches. After making a few voyages she was unfortunately lost by running upon a bank off the city of New York, where she speedily went to pieces. In 1837, Mr. Neil Snodgrass, of Glasgow, obtained a patent in this country for an invention similar to that of the *American Steam Raft*, but with improvements in the details. His plan is to form the buoyant vessels, which support the superstructure in which is contained the cabins and machinery, of sheet iron, the form of the buoyant vessel to be cylindrical at the middle portion of the length, and at about one-third of the length from each end to taper off conically. To prevent the loss of buoyancy which might arise from leakage, each of these vessels is divided transversely into separate compartments, of about four feet each in length, made air and water-tight, by forming them at first in separate lengths, and riveting them together on hoops of angle iron. To stiffen the entire vessel, four malleable iron bars are riveted thereto equidistantly and longitudinally their whole length, and along the upper side of each vessel is a beam of wood, which extends the whole length of the lower deck, and to which the whole of the joisting and beams for supporting the decks and machinery are bolted. The paddle-wheel to be placed in the channel between the floating vessels, and at about five feet before the centre of the vessels' length. In order to give a clearer idea of the minor details, we extract the marginal figure from his specification: it is a plan of the vessel on the lower deck:—



At *a a* are the conical vessels; *b b*, the lower decks laid upon transverse joisting; *c* is the chief cabin; *d* the second; *e e* promenade surrounding the cabins; *f f* four cylindrical boilers, which are all connected to one steam pipe, which is provided with a large safety valve at *g*, from whence there is a large tube to convey the waste steam into the water reservoir below. At the lower part of each boiler is a pipe provided with a two-way cock, either to feed or to blow off each boiler; and in the general steam pipe above are four valves, through which the steam passes from short vertical pipes, leading from each boiler; by shutting any one of these valves, and the feedcock beneath, appertaining thereto, such boiler may be detached, if required; *h* is the steam engine, placed horizontally, and connected by the rod, *k*, to the crank, *m*, on the end of the shaft of the paddle-wheel; *n o* the funnel; *p p* rudders hung to the stern of each of the floating vessels. On the head of each rudder is fitted a yoke or crosshead, from which a rod or chain proceeds forward along the under side of the lower deck, where it is connected by any suitable means to the pilot's steering wheel, fitted on the upper decks, and in front of the boat. The annexed figure shows an end view of the boat. *a a* the floating cylinders; *b b* the lower deck, supported upon joists, crossing the sleepers, *c c*, and also by the diagonal stays *d d*, proceeding from the cylinders, *a a*; *c*, the cabins; *f* the paddle-wheel; *g* the upper deck, surrounded by a railing; *h* the funnel.



...el on Mr. Snodgrass's plan, nearly resembling that shown in ... constructed at Glasgow. We do not know whether she ...essful, but we believe the first trials did not altogether realize ... which were formed of her performances. This might, in part, ... floating cylinder not being of sufficient dimensions to carry the upper works, for with merely the machinery on board, the cylinders were fully one half immersed.

About the same time Mr. Gemmell, of Glasgow, obtained a patent for improvements in steam vessels, part of which refer to the arrangements of the machinery on twin or double boats. Vessels of this description are generally propelled by a single wheel placed between the two boats, but Mr. Gemmell considered, that, owing to the rapidity of the current through this channel when the vessel is in motion, the paddles do not obtain sufficient reaction or resistance from the water to propel the vessel; he therefore proposed to employ two wheels, placing one at the outer side of each boat. The annexed figure is a plan of the boat and machinery:—*a a* are the twin hulls or boats, which are firmly united together by the beams *b b*, and the trusses *c c*. To avoid the liability, to which twin-boats are peculiarly subject, of having other vessels or objects running between the hulls, or of otherwise becoming entangled together, from the bows of the two boats is projected a guard, *d d*, which also serves greatly to strengthen the parts therein included. *e e* are the boilers; *f f* the engines; and *g g* the paddle-wheel.

We are not aware that any vessel has been constructed on Mr. Gemmell's plan, nor can we discover in it anything to recommend it. By placing the wheels on the outside of the vessel instead of the central channel, the extreme breadth of the vessel is augmented by the amount of the breadth of the channel, which, in the case of vessels plying on rivers, is a serious objection; and further, the paddle-wheels are no longer protected from collision with other vessels, but form the same dangerous and unsightly projections as in steamers of the ordinary construction.

It is somewhat singular that the first vessel propelled by steam in this country was a twin boat, Mr. Miller's experiments being made in vessels of this description, which he had previously constructed without reference to the employment of steam as the propelling power.

SECTION III.

THE CONSTRUCTION AND ARRANGEMENT OF MARINE ENGINES, BOILERS, CONDENSERS, &c.

Peculiar construction of Marine Steam Engines generally.—Beam Engine.—Lever Engine.—Napier's Direct Action Engine.—Seaward's Gorgon Engine.—Penn's Direct Action Engine.—Steeple Engine.—Galloway's Inverted Cylinder Engine.—Humphrey's Trunk Engine.—Parkyn's Sliding-cover Engine.—Maudslay's Concentric Cylinder Engine.—Maudslay and Field's Double Cylinder Engine.—Hick's Inverted Double Cylinder Engine.—Maudslay and Field's Direct Action Screw Propeller Engine.—Brunel's Inclined Cylinder Engine.—Penn's Oscillating Engine.—Borrie's Rotatory Engine.—Condensation of Steam.—Seaward's Salt-water Gauge.—Maudslay and Field's Pumps.—Brunel's Condenser.—Napier's Condenser in the "Kilmun."—Howard's Condenser.—Dr. Church's Condenser.—S. Hall's Condenser in the "Wilberforce."—S. Hall's Salt-water Still.—Parallel Motion.—Reversing Motion.—Seaward's Slide Valves.—Morgan's Balance Valves.—Piston-slide Valves.—Expansion Valves.—Snodgrass's Expansion Valves.—Bourne's Slide Expansion Valves.—Ordinary Steam-boat Boiler.—Separate Elliptical Boilers.—Boilers of the "Syrius."—"United Kingdom" Boilers.—D. Napier's Tubular Marine Boilers.—Safety Valves.

Marine engines, in general, differ in their construction from those used on land in several points. As the weight of the machinery of steam-vessels, and the space which it occupies, necessarily excludes a portion of the cargo, it becomes an object of the greatest importance to diminish that weight and space to the utmost degree compatible with the requisite stability and means of working. These essential qualifications should be sought for by the adoption of the most judicious forms for obtaining the greatest strength and solidity with the least quantity of material. Marine engines should also be as simple as possible, consistently with their efficient performance: as they are exposed to severer trials than any other class of engines, they are consequently more liable to derangement; and the delays and expense attending repairs become serious evils, as the profitable employment of the vessel is thereby suspended.

An important consideration is, the position of the centre of gravity, which should be placed as low as possible, in order to obtain the greatest degree of stability for the vessel; as a very slight heel or lateral inclination of the vessel materially increases the load upon the engines, and detracts from the speed.

From these and other considerations, the arrangements and proportions commonly observed in land engines require to be modified for marine purposes. The length of the stroke is much shorter in proportion to the diameter of the cylinder than is usual in land engines; the length of the stroke seldom exceeding the diameter of the cylinder by more than a sixth, and frequently being even less than the diameter. The beam likewise is shorter, being generally rather less than three times the length of the stroke; and instead of having only a single beam, the centre of which is placed considerably higher than the centre of the shaft, there are two beams working outside the side frames, and the centres are placed as low down as the vibration of the beam will admit, the connecting rod working upwards instead of downwards. This arrangement originated in Scotland, and, we believe, with Mr. David Napier, of Glasgow.

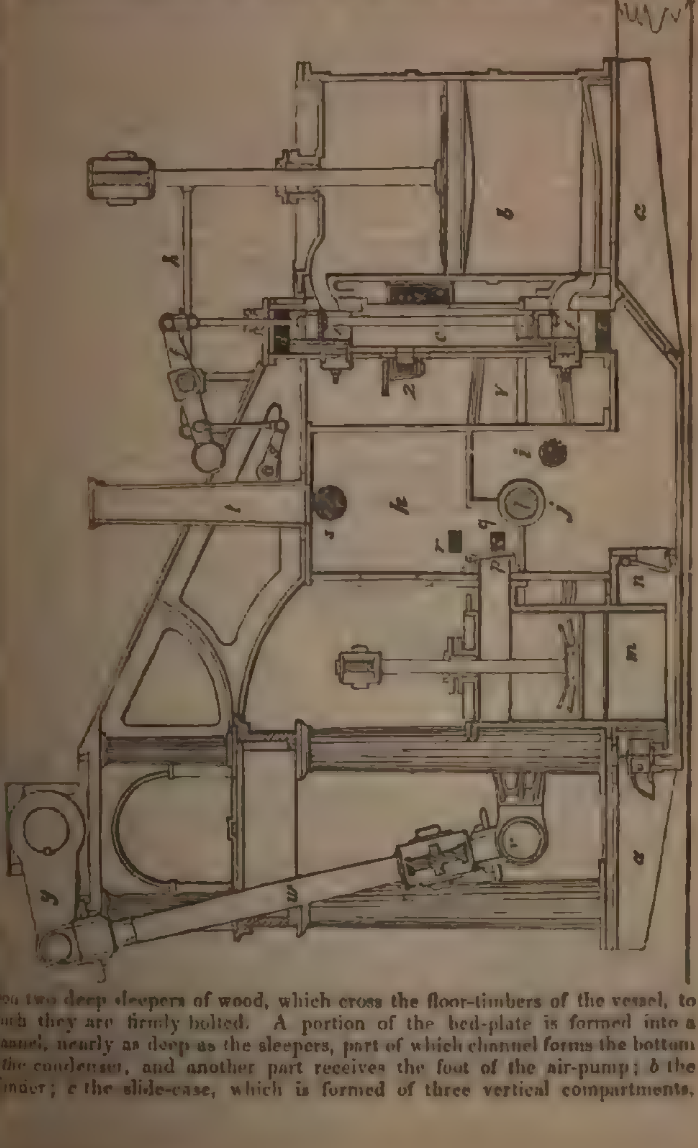
The shaft is considerably higher than the top of the cylinder, and the frame which carries it is braced to the cylinder by a strong diagonal truss. As an unlimited supply of injection-water can be obtained without the use of a pump, the cold-water pump is dispensed with, and also the cold-water cistern, which, in land engines, usually surrounds the condenser. The motion of the vessel precludes the ordinary mode of feeding the boiler by means of a feed-head and a regulating float; the water is therefore conveyed direct from the feed-pump to the boiler, and the supply is regulated by hand, by means of regulating valves or cocks.

Owing to the rapidly corrosive action of sea-water upon iron, whether malleable or cast, it is found necessary to construct all the moving parts of the engine which are exposed to it of copper or gun-metal; the air-pumps are

therefore lined, and the air-pump rods sheathed, with copper or gun-metal, and all the valves and cocks, and the plungers of the feed and bilge pumps, are made of brass or gun-metal.

Marine engines are generally of the class known as Beam Engines, in which the action of the piston is transmitted to the crank by a beam, whose fulcrum is in the centre of its length; we shall therefore commence our description with one of this class.

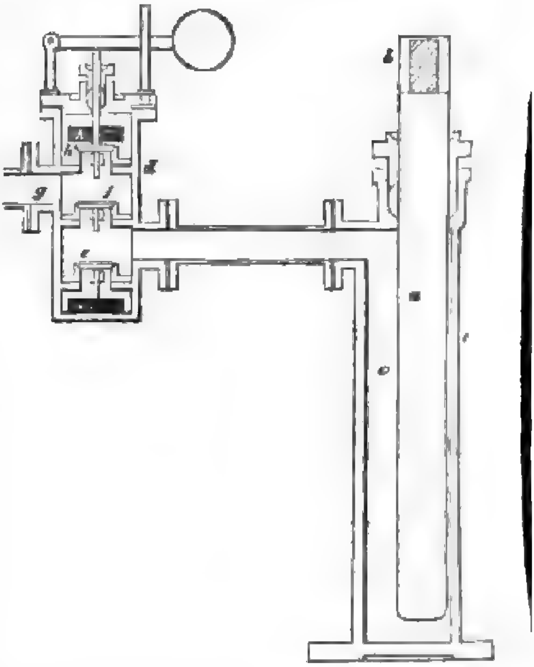
Beam Engine.—The annexed figure represents a longitudinal section. At a is the foundation-plate, on which the engines are erected; it is supported



upon two deep sleepers of wood, which cross the floor-timbers of the vessel, to which they are firmly bolted. A portion of the bed-plate is formed into a channel, nearly as deep as the sleepers, part of which channel forms the bottom of the condenser, and another part receives the foot of the air-pump; b the cylinder; c the slide-case, which is formed of three vertical compartments,

connected at top and bottom by the apertures *d d*; the middle compartment forms the steam-chamber, and the side compartments are the eduction passages; *e* is the steam inlet; *f* the slide-valve, formed of two short slides, connected by a rod, which is found preferable to a single long slide for large engines, as the latter is liable to warp; the slides, which on the back form about one-third of a circle, are pressed up to the seats by screws at the back, acting upon a block of metal, faced with a thick sort of mat, made for the purpose; *f* the valve lever, working upon the shaft of the parallel motion as a fulcrum; the motion of the eccentric is communicated by the intermediate lever *g*; *h* the parallel bar; *j* the condenser, cast in one piece, with *k* the hot-well, and bolted to the foundation-plate; *i* the injection pipe. A tube, or cylindrical passage, is cast in the condenser, through which pass the gudgeons *l* of the working beam; these gudgeons are very securely wedged into bosses, cast on the sides of the condenser, and the brass bearings are fixed in a boss in the centre of the beam; *m* the air-pump; *n* the foot-valve; *o* the blow-through valve, through which the air and water are blown out of the condenser at starting the engine; *p* the delivery valve, through which the water passes into the hot-well; *q* the passage leading to the feed-pump; *r* the connexion with the relief valve; *s* the passage by which the waste water is carried off into the sea; *t* an air-vessel; *v* the beam; *w* the connecting rod; *y* the crank; *x* the blow-through cock, connecting the steam-chamber of the slide-case with the eduction passage; this cock is opened previously to starting the engines, for the purpose of expelling the air from the engines, or, as it is termed, *blowing through*.

The feed-pump and bilge-pump are worked from the cross-head of the air-pump, and could not be shown in the sketch. The annexed figure represents, on a larger scale, a section of the feed-pump, with its valves. *a* is the plunger, attached to the cross-head *b*, and working through a stuffing-box in the pump-barrel *c*; *d* is the valve-box attached to the side of the hot-well; *e* is the suction-valve, through which the water is drawn from the hot-well into the pump by the rise of the plunger. On the descent of the plunger the water is driven out at the valve *f*, along the feed-pipe *g* to the boiler, unless the regulating valves or cocks on the boiler should be quite closed, when it raises the loaded valve *h*, and returns to the hot-well by the aperture *k*. The load per square inch on the valve *h* must somewhat exceed the pressure per square inch of the steam in the boiler.

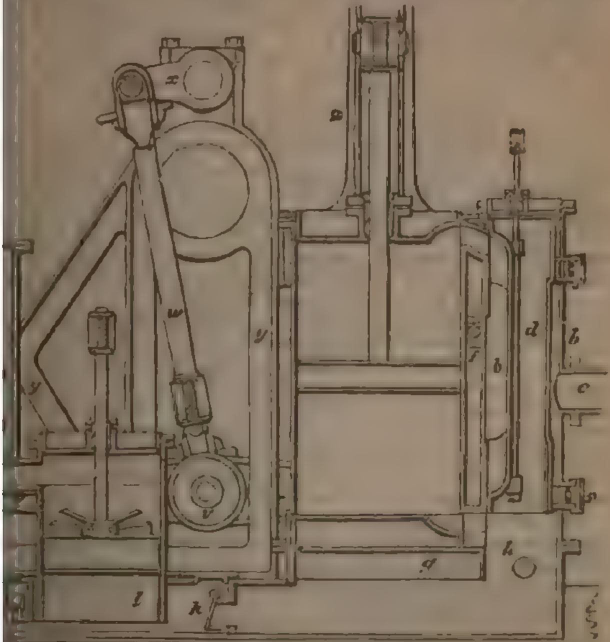


In addition to the bolts, by which the cylinder, condenser, and side-frames are screwed down to the foundation-plate, there are twelve strong bolts, called

..s bolts, which are passed from the outside through the floor-..pers, foundation-plate, and bosses on the cylinders, condensers and ..and screwed as firmly as possible by strong nuts. These bolts are ..iron tinned, in order to resist the corrosion of the sea-water.

..gement of the Beam Engine is, perhaps, that which is best adapted ..use in steam-vessels, as all the parts admit of easy access; the ..f moving parts on each side of the beam nearly counterbalance each ..e requisite pumps are easily attached; but their weight and the ..ccupy have, in the progress of the improvements which marine ..e undergone, been deemed very serious drawbacks; and, at present, ..s to be setting in favour of what are termed "direct-action" ..t of the leading engineers having adopted each some particular ..for dispensing with the side-beams. Several of these deviations ..mon form we shall now proceed to describe, commencing with one ..be considered as intermediate between the Beam and the Direct-..es; it is commonly termed a "Lever Engine," the action of the .. transmitted to the crank by a lever, whose fulcrum is at the

..ne.—The accompanying figure represents in section an engine .. *a* is the cylinder; *b* the slide-case; *c* the steam-pipe; *d* the slide, ..mmonly known as the long side, which is hollow, and forms the ..age; *f* the way-shaft, by which the valve is worked; *g* is the con-



..in one with the bed-plate, and forming a pedestal to the cylinder; ..-pipe; *k* the foot-valve; *l* the air-pump, inserted in a chamber ..e bed-plate; *m* the blow through valve; *n* the delivery valve; ..l; *p* the waste-water passage. The feed-pumps may be supposed ..d as in the engine first described, *q* and *r* being the passages con-..e pump; *t* is the beam gudgeon; *v* the beam; *w* the connecting-

rod; *x* the crank; *y* the side-frame, firmly secured to the bed-plate, and to strong flanges cast on the cylinder; *z* the guides in which the cross-head moves.

This arrangement appears to us to be inferior to the preceding one, and to possess few recommendations. Very little space is gained, or weight saved; and as no longer cylinder can be employed than with a Beam Engine, the crank of course must be shorter. In the Beam Engine, likewise, the parts acting on each half of the beam nearly counterbalance each other; but in the Lever Engine the weight of the steam and air-pump pistons, side-rods, and connecting-rod, acts all on one side of the fulcrum, and therefore requires to be counterbalanced, which is sometimes done by having one of the paddles of the wheel formed of cast iron, of the requisite thickness. Lever Engines are very common in boats on the Humber.

Napier's Direct-action Engine.—The annexed figure represents a Direct-action Engine, which in appearance greatly resembles the preceding, the small side-beams being retained; but solely for the purpose of working the pumps. It was applied by Mr. David Napier, of Glasgow, to the "United Kingdom" steam-vessel, at a period when it was considered as of great dimensions.

In the annexed engravings, *Fig.* 1 represents an end view of the two engines, and *Fig.* 2 a side view of one of them.

The cylinders *a a* are of cast iron, and fixed to a framing, which is bolted to the bottom of the boat. The piston-rods *b b* are keyed at the upper ends to the cross-heads *c c*; to the exterior ends of which are attached the connecting-rods *d d*. The lower ends of these connecting-rods are inserted in the fork ends of the beams *e e*, which vibrate upon a shaft *f*, the bearances of which rest upon the top of the condenser *g*. In the same forks are inserted the ends of other connecting-rods *h h*, which are keyed at their upper ends to cross-heads *i i*. In the centre of these cross-heads are bosses large enough to receive the rods *j j*, which extend to the crank pins of the cranks *k k*. These cranks are fixed to the main shaft, which rests upon the bearances *l l*, upon the arches *m*, which are bolted to the cross-beam, as at *n*. The shafts are shown as broken off at the outer ends, but they extend to the outside of the paddle-wheel.

The side beams *e e* are not straight, but have two bends, represented by the lighter parts of the shading; the ends near the cylinder being therefore much farther apart than the opposite ends, so that they may take up as little room as possible, by lying close to the respective parts of the machinery. They are also forked at the end nearest the air-pump *o*, so as to admit the insertion of the pump-rods *p*, which are connected at their upper ends to the cross-head *q*, in a bush, in the centre of which is keyed the air-pump rod *r*. Connecting-rods *s* are attached at *t* to the side-beams *e*, and at their upper ends to cross-heads, which are connected, as at *u u*, (*Fig.* 1,) to two rods, which work the plungers of two feed-pumps *v*, for supplying the boiler. *j* is the apparatus for blowing through, previous to starting the engine. It consists of a cock, which opens or closes a communication between the steam-chest and condensers, by turning the handle. The rod and lever *x* are for the purpose of regulating the quantity of injection water which enters into the condenser, by a pipe from the outside of the vessel, and can be increased and lessened in quantity by turning a cock to which the rod *x* is attached; *y* is the hot-well, into which the condensing water is discharged from the air-pump. The feed-pumps are supplied with water from this hot-well, through the medium of a pipe, the overplus being discharged through the side of the vessel by another pipe which is not seen.

Seaward's Gorgon Engine.—The annexed engraving represents an arrangement for a Direct-action Engine, devised by Messrs. Seaward, and commonly known as the "Gorgon Engine," from having been first employed in a government steamer of that name. *a* is the steam cylinder, and *b* the piston-rod, which is connected to the crank *c* by the connecting rod *d*. The head of the piston-rod is guided vertically by the parallel motion as follows:—*e* is a rocking standard, carrying at its upper end the fulcrum upon which the beam *f* turns.

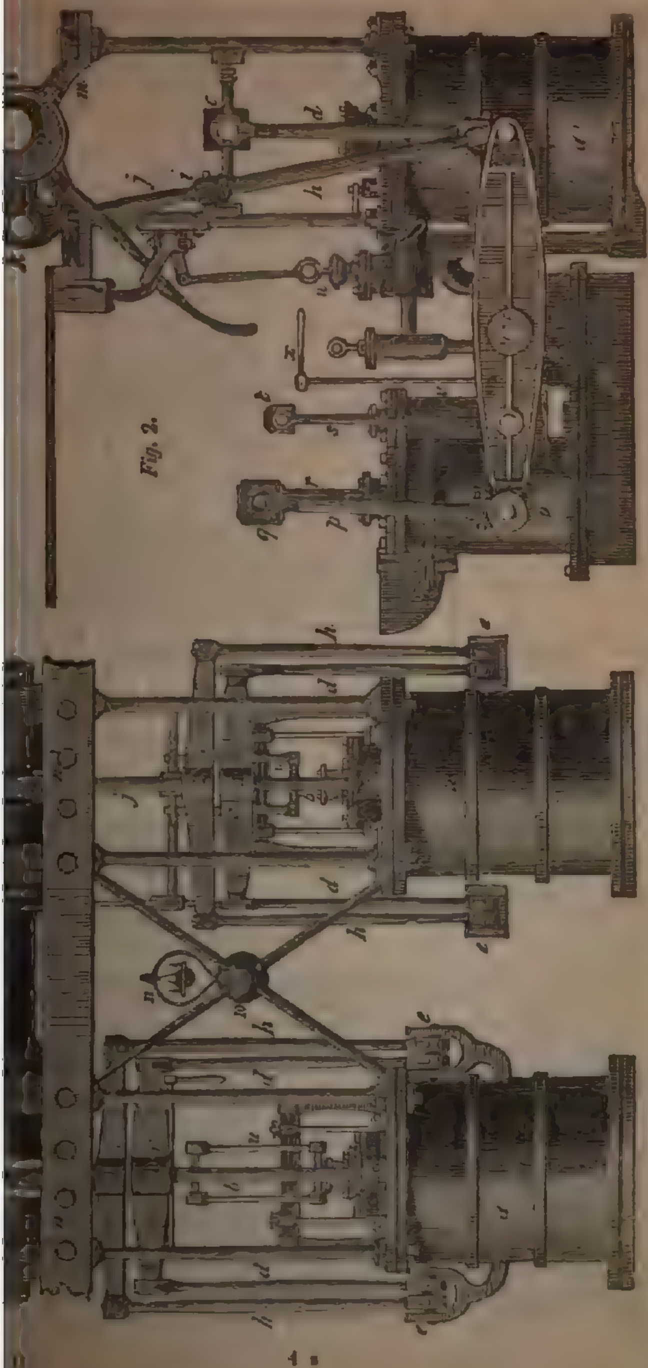
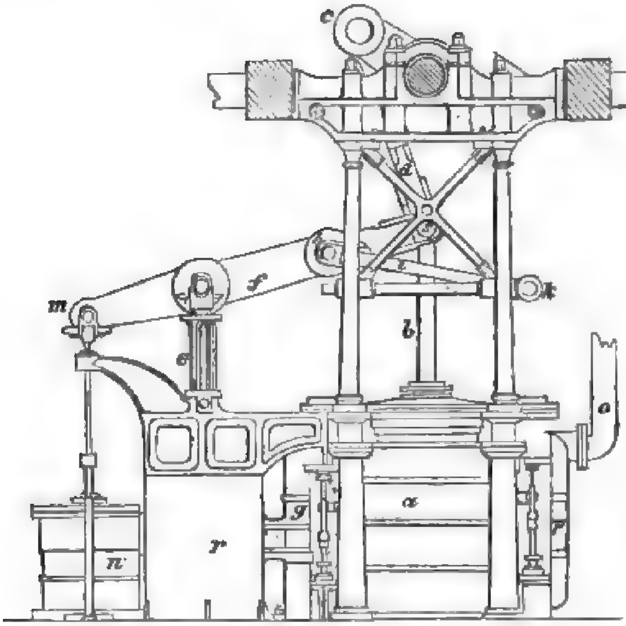


Fig. 2.

NAPIER'S ENGINE.

This beam is jointed at *g* to the cross-head of the piston-rod, and at *k* to the radius bar *i*, which turns upon *k* as a centre. The outer end *m* of the beam serves to work the air-pump *n*. The slide-valves are of a peculiar construction, patented by Mr. Seaward, and which will be described in the latter part of this

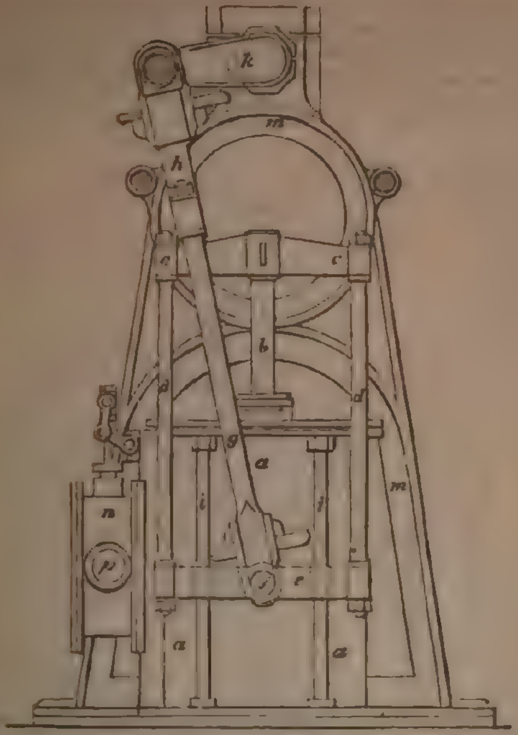


article. *o* is the steam-pipe, by which the steam enters the slide-case *p* of the induction slides; and *q* is the slide-case of the eduction slides, which is connected with the condenser *r*, the upper portion of which forms the hot-well.

Messrs. Seaward have constructed several pairs of engines of this description, of large dimensions, for the government, which may be considered a proof of the efficiency of the plan.

Penn's Direct-action Engine.—This arrangement of marine engines, shown in the opposite engraving, originated, we believe, with Mr. Penn, of Greenwich, who has applied it to some steam-boats on the Thames. At *a* is the cylinder; *b* the piston-rod, carrying the cross-head *c c*; this cross-head consists of four arms, branching diagonally from the centre. On each side two side-rods *d d* are suspended from the extremities of the arms *c c* of the cross-head, and are attached at the lower end to a bar *e*. In the centre of this bar is a pin *f*, to which the forked end *g* of the connecting-rod *h* is coupled; *i i* are two guide-rods, upon which the bar *e* slides, the rods passing through brass bushes attached to the side of the bar; *k* is the crank, and *m* the side-frame; *n* the slide-case, and *p* the steam-pipe.

When only one engine is employed, instead of a forked connecting-rod the rods *g* are sometimes connected directly to the crank, the pin of which is equal in length to the distance between the two connecting rods *g*. By this means a longer stroke may be obtained in the same height, and the connecting rod is somewhat lighter.

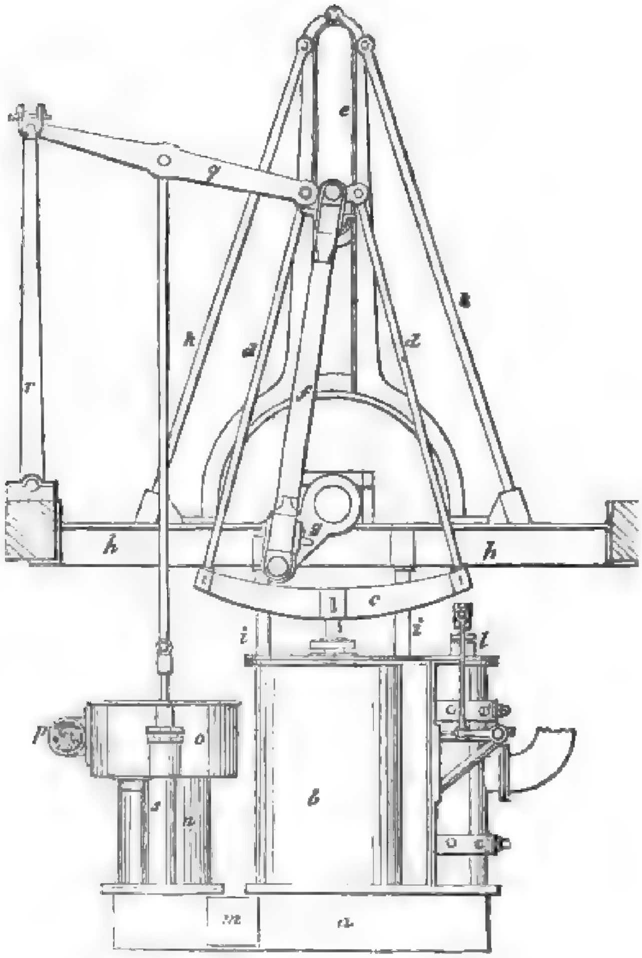


The Steeple Engine.—This arrangement is extensively adopted on the Clyde, with some variations in the minor details, according to the views of different makers. At *a* is the condenser, constituting the base of the cylinder *b*. the cross-head *c* of the piston-rod, instead of being parallel to the shaft, as is usual, stands at right angles to it; and from the ends of the cross-head rise two rods *d d*, which are connected at top, forming with the cross-head a triangle. Through the apex of this triangle passes a pin, the ends of which work in guides *e*, to cause the piston-rod to preserve a parallel motion. The connecting-rod *f* is suspended from the central part of the pin, and the lower extremity is connected to the crank *g*, which revolves within the triangle. The frame *h*, which carries the shaft, is supported upon four short colums, which rest on the cylinder; and the vertical guides *e* are braced to this frame by the rods *k k*; *l* is the slide-valve: *m* a bonnet over the foot-valve: *n* the air-pump; *o* the hot-well on the top of it: *p* the waste pipe. The air-pump is worked by the beam *q*, which is supported at one end by the rocking standard *r*, and at the other is connected to the apex of the triangle. The feed-pump *s*, and the bilge-pump on the other side of the air-pump, are worked from the cross-head of the air-pump.

We believe Mr. David Napier introduced the plan of suspending the connecting rod above the crank in steam vessels, but Trevithick employed a similar arrangement in his steam-carriage in 1802.

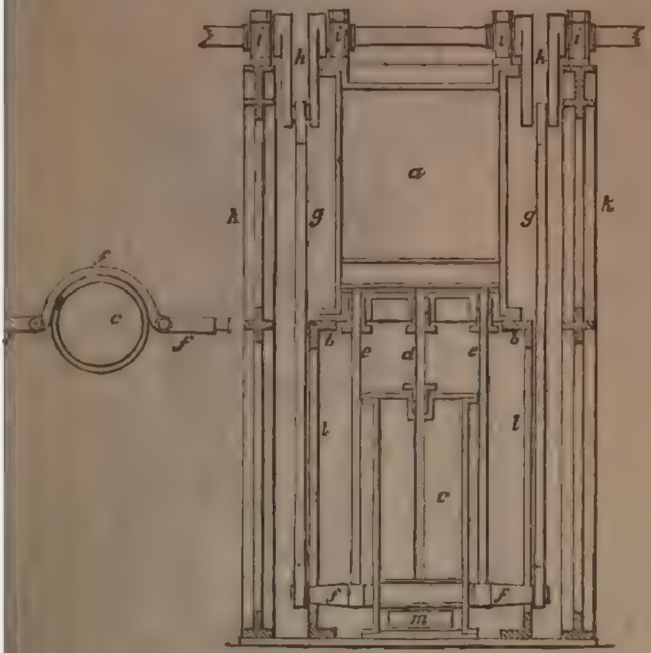
The motion for the air-pump, shown in the sketch, (p.692) is not that which is commonly employed, but is the best which we have noticed. Sometimes the air-pump is worked from one end of the cross-head of the piston-rod, and the bilge-pump and feed-pump from the opposite end; and in some vessels the slide-valve is at the side of the cylinder, and two air-pumps, of small diameter, are worked from the extremities of the cross-head.

This arrangement, like that of the Oscillating Engine, admits of stroke, without carrying the shaft very high; and the parts in motion few, the friction is proportionately small. It has, however, some serio advantages; a considerable weight lies at a great height above the ce gravity; the oblique thrust of the connecting-rod acts with some le against the upper framing; and the engine-house requires to be carried the deck.



Galloway's Inverted Cylinder Engine. — The engraving on the op page exhibits an arrangement for marine engines for which Mr. Galloway obtained a patent; and which has, we believe, been adopted ir or two vessels plying on the Humber. At *a* is the cylinder, supported the frame or platform *b b*; *c* is the air-pump, placed beneath the cylinder concentric with it: the piston-rod *d*, of the air-pump, passes through a sta box, in the cover of the air-pump, and through another stuffing-box i

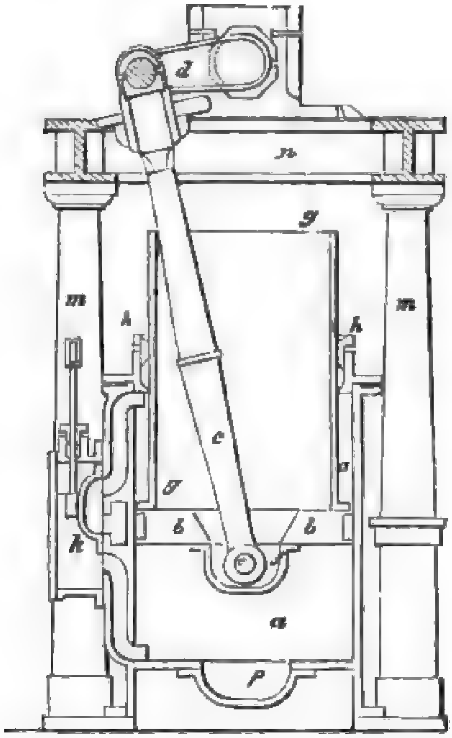
of the cylinder, and is attached to the steam piston. Two piston-rods, pass down through stuffing-boxes in the bottom of the cylinder, and are fixed into a cross-head, *f*, which is curved so as to encompass one half of the trunk, as shown in the plan separately given of it; *g g* are two connecting rods proceeding from the bearings of the arms of the cross-head to the crank



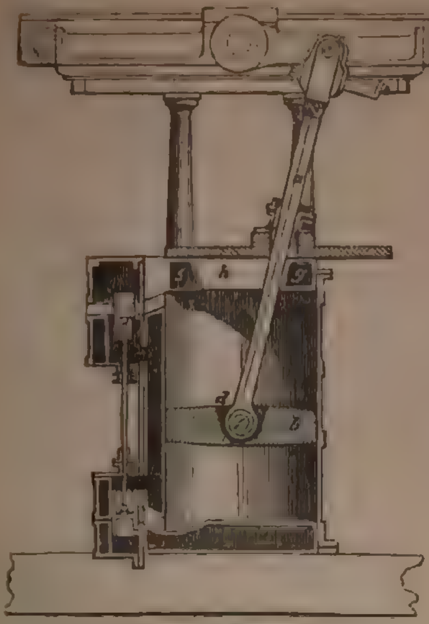
i i are the plummer blocks, which carry the paddle shaft; two of these supported by the cover of the cylinder, and the other two by the side frames *k k*; *m* is the neck in which is placed the foot valve, connecting the cylinder with the condensers; *l l* are the guides in which the cross-head *f* works.

Humphery's Trunk Engine. Mr. Francis Humphery obtained a patent in for an arrangement in which not merely the side beams, but likewise the cross-head was dispensed with: the power of the engine being transmitted from the piston to the crank by the connecting rod. To this novel form of engine he gave the distinguishing name of the Trunk Engine: it is remarkable for originality, simplicity, and ingenuity. The annexed cut (p. 691) shows a vertical section of the engine. *a* is the cylinder; *b* the piston; *c* the connecting rod, the upper end of which is connected to the crank *d*, and the lower end passes through an aperture in the piston, and carries a pin, *e*, the ends of which work in bearings attached to the under side of the piston; *f* a box or recess enclosing the bearings and end of the connecting rod. The connecting rod works within a case or trough, *g*, which is bolted at bottom to the top of the piston, and which slides in a stuffing-box, *h*, on the cylinder cover. The sides of the trough are straight, and parallel to each other; and the ends semicircular; the width is just sufficient to receive the connecting rod without rubbing, and the distance between the semicircular ends is such as to allow the vibration of the connecting rod during the revolution of the crank. *i* the slide valve, and *m m* the columns supporting the entablature *n*, which

carries the plummer blocks, in which the shaft revolves; *p* bonnet, cov the manhole in the cylinder bottom. A pair of engines of this descrip 90 horse-power, were constructed by Messrs. J. & E. Hall, for a packet na the *Dartford*.



Parkyn's Sliding-Cover Engine.—The adjoining cut is explanatory c direct-action engine invented by Mr. Parkyn, which resembles the prece in the circumstance of the piston-rod serving also as the connecting rod, by a somewhat different disposition. *a* is the rod which serves at once the p pose of the ordinary piston rod and connecting rod, being attached at the lo end to the piston *b*, and at the upper to the crank pin *c*; *d* is a recess in piston *b*, for the reception of the lower end of the rod *a*; *e* a cross pin pa through the body of the piston *b*, and the eye-hole *f*, in the lower end of rod *a*, turning freely upon the pin. The motion of the crank and connec rod *a* being angular and variable, while the piston *b* moves uniformly in vertical plane, in order to bring the two motions into harmony with each ot the following arrangement is adopted. In the centre of the cylinder cov and in a line parallel with the crank, there is an elongated slit, *h*; immediately over this there is a supplementary steam-tight cover *i*, w moves backwards and forwards at right angles to the main shaft, in confor with the varying positions of the crank and connecting rod *a*, much in same way as in a lathe the tool carriage of a slide-rest moves on its bed. under portion of the stuffing-box has two arms or pins, which turn in sui bearings in the upper or supplementary cover *i*, whereby the stuffing-bo enabled to adapt itself to the line of the piston and connecting rod throug the entire revolution of the crank.



Parkyn's Engine.

Fig. 1.

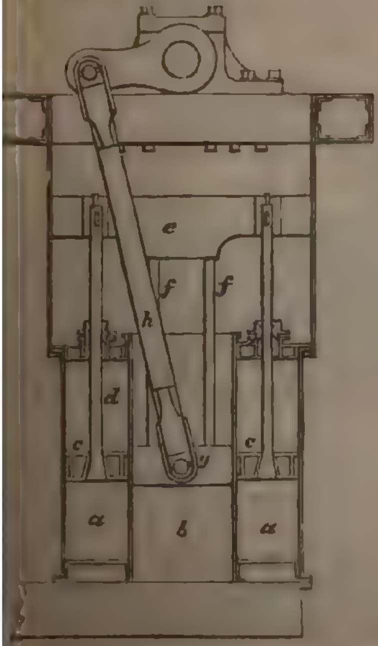
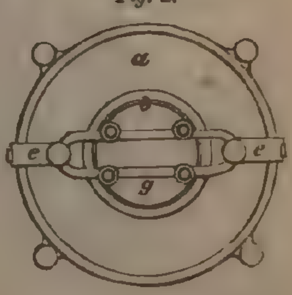


Fig. 2.

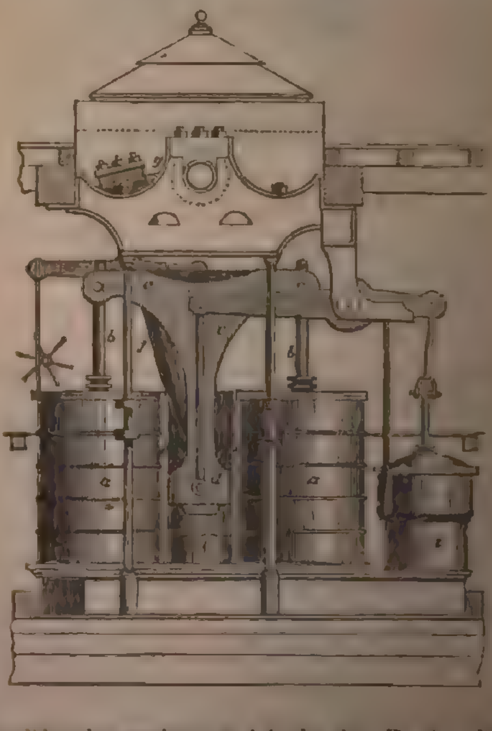


Maudslay's Annular Cylinder Engine.

Maudslay's Annular Cylinder Engine.—This is a new arrangement, patented by Mr. Joseph Maudslay, in 1841. We understand that several engines have been constructed on this plan by the firm of Maudslay, Sons, and Field. Its distinguishing feature is the annular form of the working cylinders. *Fig.* 1 (p. 694) is a sectional elevation, and *Fig.* 2 a plan. At *a* is the exterior steam cylinder; *b* a smaller cylinder, fixed in the centre of the steam cylinder; *c c* the piston of an annular form, and working in the space between the two cylinders: *d d* the piston-rods; *e* the cross-head; *f f* rods uniting the cross-head with the guide block *g*, which moves in the cylinder *b*. From a pin in the guide block, the connecting rod *h* is connected with the crank. The air-pump and other parts may be attached to the engine in various convenient ways.

Maudslay and Field's Double Cylinder Engine.—The peculiarity of this engine consists in there being two steam cylinders, each of half the area necessary for the intended power, combined so as to form one engine, and placed so far apart, as to leave a space between them for the connecting rod, and the lower end of a T-shaped cross-head, to which the connecting rod is attached, to work in; the piston-rods being attached to the horizontal extremities of the T cross-head, and moving up and down simultaneously with it and with each other, whereby the combined action of both pistons is applied to one crank of the paddle shaft. In the accompanying drawings *Fig.* 1 exhibits a longitudinal elevation of one of the engines, consisting of two steam cylinders

Fig. 1



worked by one slide valve, as shown at *k* in the plan *Fig.* 2. *Fig.* 3 exhibits a transverse section of a portion of the vessel, with one of the engines in elevation. At *a a*, *Fig.* 1, are the two connected working cylinders, *b b* the piston-rods, the upper ends of which rods are affixed by keys to the cross-head

at the lower end of the cross-head there is a slider *d*, working between *e e*, fixed on the outer surfaces of the cylinders; to this slider *d* one end connecting rod *f* is attached, the other end of that rod being attached to crank *g* of the propelling shaft.

From this arrangement it will be perceived, that by the simultaneous ascent descent of the two pistons in their working cylinders *a a*, the rods *b b* will cause the cross-head *c c* to move perpendicularly up and down between its guide bars *e e*, and in so doing to raise and depress the slider *d* with the connecting rod *f*, which rod will by that means be made to give a rotatory motion to the crank *g*, and thereby cause the paddle-wheel shaft to revolve. The air-pump, and the feed and bilge-pumps are worked by the lever *m*, which is connected to the slider *d* by the rods *n*.

Fig. 2.

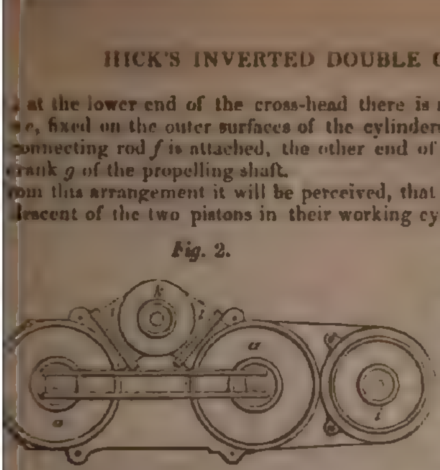


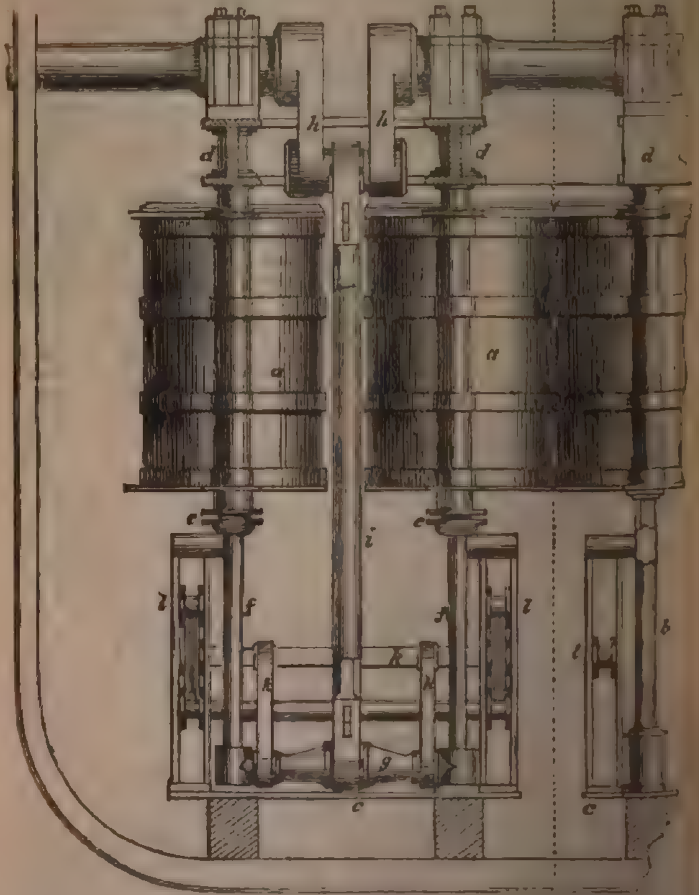
Fig. 3.

The mode of adapting the steam valve to the combined cylinders is shown in *Fig.* 2. The steam is admitted to, and withdrawn from, these cylinders by one slide valve *k* common to both, through a pipe, in the ordinary way; the steam passing through the curved passages or tubes *l l* into both cylinders. There is also a narrow passage of communication always open, by which the steam is allowed to pass from one cylinder to the other, for the purpose of keeping the pressure equal at all times in both cylinders.

The advantages stated to be realized by this arrangement are: 1. Simplification of construction; 2. More direct action on the crank; 3. Saving of space and weight of material; and 4. Obtaining the greatest length of stroke and connecting rod in a given height, without any lateral pressure on the pistons or piston-rods.

Hick's Inverted Double-cylinder Engine.—This arrangement resembles the preceding one by Messrs. Maudslay and Field in the circumstance of each engine being composed of two cylinders, but in all other respects it is different. The cylinders in this engine are inverted, and the four cylinders composing the pair of engines are ranged in a line across the vessel. The engraving shows a transverse section of a portion of one side of the vessel, with an end view of engines. At *a a* are the cylinders, standing upon four strong wrought-columns, only one of which is shown, in order to bring the piston-into view. The columns rest on, and are secured to, the foundation *c*; and passing through suitable bosses on the sides of the cylinders the entablature plate *d*, and the crank pedestals above. The cylinders placed at a sufficient height from the bottom of the vessel, to allow the -rods to work downwards. The two piston-rods *f f* are connected

together by a cross-head *g*; the stuffing-boxes *e e* are of double form, or in oth words they have a space for packing both at top and bottom, being furnish with self-acting oil cups for lubricating the rods. The power is transmitt directly from the main cross-head *g* below to the cranks *h h* above the cylinders, by the connecting rod *i*; the two piston-rods *f f*, and the connecting cross-bea

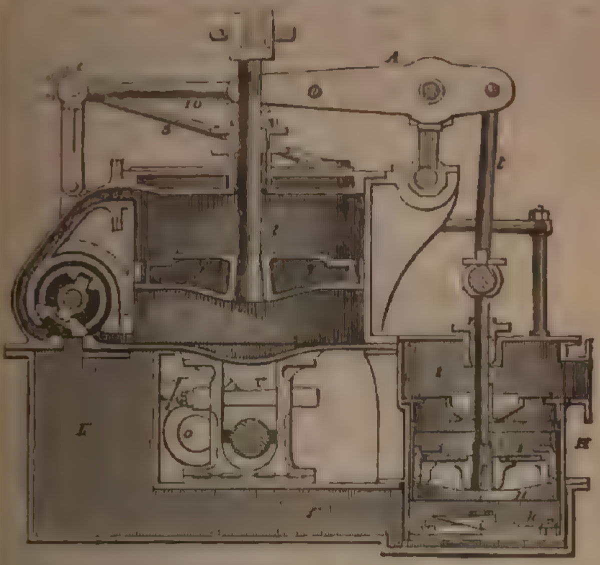


g, are further secured and made to work uniformly together by means of strong vibrating frame *k* of cast iron, forming part of the parallel motion; an which, with the side levers *l*, serves also to work the air-pump as well as th feed, bilge, and brine-pumps. Each cylinder is furnished with a separate sli valve, the two being connected together by a cross-head, worked by on eccentric motion. The object of thus dividing the valve is to shorten the length of the steam ports; the valves being brought much closer up to the face of the respective cylinders than would be the case if one only were used for both The condenser is placed immediately underneath the slide valve case, and th air-pump, foot, and discharge-valves, are similar in construction to those ordinary engines. The air-pump and condenser are connected together by

ge underneath the foundation plate. The waste water is discharged from ot-well by an overflow-pipe through the side of the vessel.

audslay and Field's Direct-action Screw Propeller Engine.—This engine is lly designed for dispensing with the multiplying wheels, or chains and s, hitherto employed, between the engine crank and the shaft of the propeller, in order to produce a suitable speed in the latter.

e annexed figure represents a transverse vertical section of the engines; are ranged side by side in a line coincident with the line of the propeller , and immediately over the engine shaft, which is concentric with the pro- shaft, and is connected thereto by a coupling, which admits of the shafts g readily disconnected, when the vessel is required to be propelled by the alone. In order to obtain the requisite speed, the engines are constructed

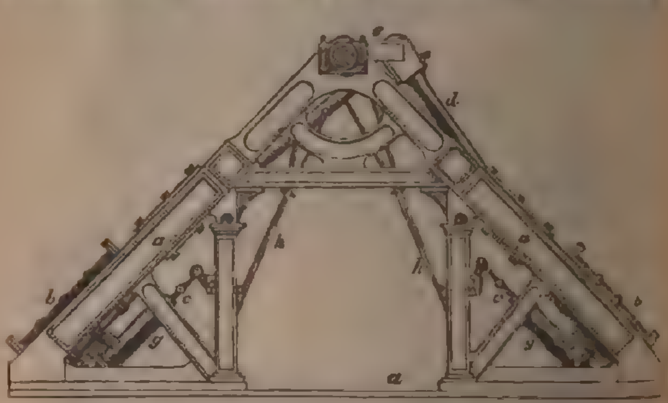


ork with a very short stroke, and a new kind of slide valve is employed, h facilitates the rapid exhaustion of the cylinder. At *a a* is the cylinder, orted on the upper part of the condenser *b*, and on a projecting flange on air-pump *c*; *d* is the engine shaft; and *e* one of the engine cranks keyed on, to which the force of the piston is transmitted from the cross-head *f* of piston rod, by the connecting rod *g*. The slide valve is composed of a w segmental plate *h*, working in the cylindrical steam case *k*; the space e the slide plate being occupied by the steam, and the cavity on the under of the plate communicating with the condenser by the passage *m*. The e works on its axis with a vibratory motion, and thus brings each side of piston into communication alternately with the steam and the condenser.

he foot of the air-pump is inserted in a flat prolongation of the condenser; the foot valve *n* is situated in the bottom of the pump. The delivery valves *p* in the bucket and pump cover are composed of annular plates, which and fall vertically between guides, and admit of the escape of the air and , both at the periphery, and at the central aperture of the annular plate. upper portion *q* of the air-pump forms the hot well, from which the supply he boilers is drawn by the feed pumps; and the surplus passes off by the water-pipe, which is connected to the aperture *r*. The air-pump is ed from the parallel motion in the following manner: *s* is the parallel bar,

which is connected at the end *t* to the cross-head *f*; and at the point *v* to the radius rod *w*, the centre of motion of which is at *x*. The parallel bar is extended beyond its centre of motion to *y*, from which the cross-head of the air-pump is suspended by links, or a connecting rod *z*. The feed and bilge-pumps are connected to the cross-head of the air-pump.

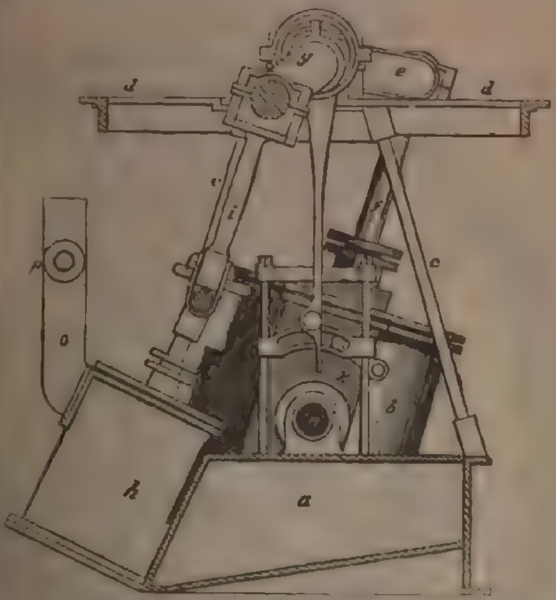
Brunel's Inclined Cylinder Engine.—This arrangement was patented by Mr. Marc Brunel in 1822, and he employed an engine on this plan for pumping in the great subterraneous work of the Tunnel under the Thames. It has likewise been adapted in several steam boats. The chief improvement consists of an arrangement of the working cylinders, by which the connecting rods of two engines are made to give motion to the same crank. The annexed figure, which represents an elevation of the engine, will afford a correct idea of it. At *a a* is a strong triangular frame of cast-iron: within are fixed the two cylinders *b b*. These cylinders are inclined towards each other, so as to form an angle of 102°, which angle Mr. Brunel considers to be preferable to any other for imparting a rotatory motion to the crank by the alternating action of the piston-rods; *c c* are the piston-rods; *d d* the connecting rods attached to the crank *e*, which gives motion to the paddle shaft. The piston-rods are



supported upon rollers, running upon guide plates to preserve their parallel motion during the stroke. The steam is received from the boilers into the small cylinders *g g*, and by the action of the pistons therein is alternately admitted into one end of the working cylinders, and a passage opened for its escape at the other. The action of the piston is regulated by the eccentrics placed on the paddle shaft, as shown in *Fig*. 2. These eccentrics give motion to the rods *h h*, which, by the intermediate levers *i i*, operate upon the pistons in the small cylinder. This arrangement, it will be seen, is better suited to high-pressure engines than to condensing ones, as it affords no convenient mode of working the air-pump. In a French Post-office packet, on the Dover Station, the engines were somewhat similarly arranged; the two engines impelling one crank: but the cylinders were on the oscillating principle.

Penn's Oscillating Engine.—But of all the arrangements of direct action engines, that which admits of the greatest length of stroke in the smallest compass, and which, perhaps, is also the simplest, is the Oscillating Engine, invented, as we have already mentioned, by Mr. Witty. The very extensive adoption of this form of engine for steam vessels, is mainly owing to the example of Messrs. Penn and Son, of Greenwich, who for some years past have employed it in preference to all others; and, by their judicious mode of construction, added to the exquisite style of workmanship, have attracted such notice to the arrangement that most of the leading engineers have to some extent adopted it, and it bids fair to supersede most other forms.

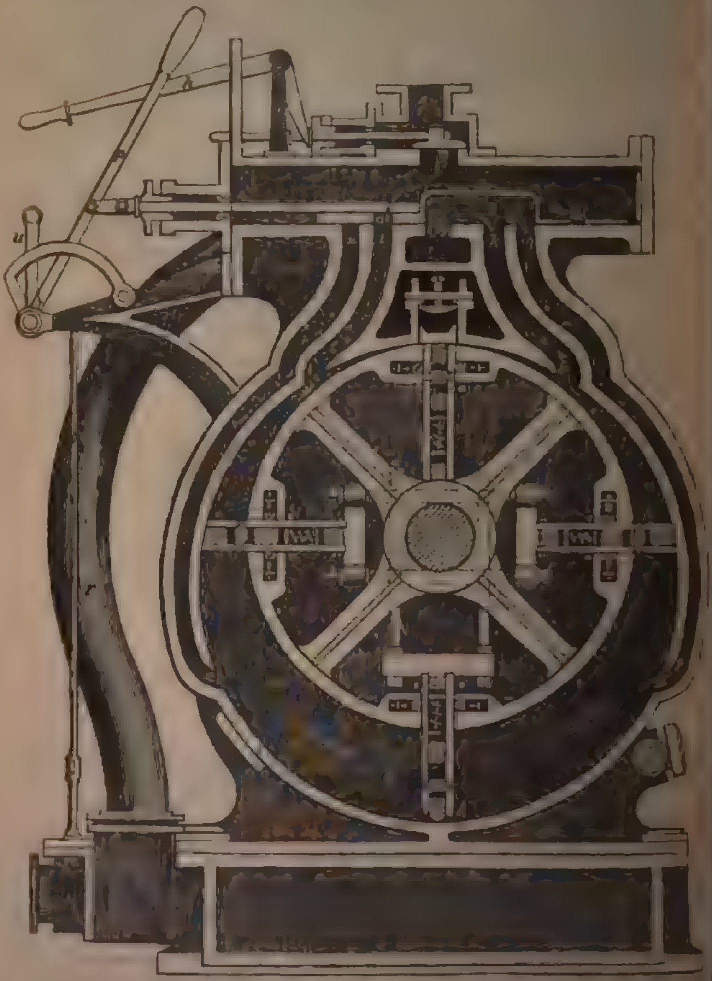
annexed cut represents an arrangement of this description of engine by Messrs. Penn in a vessel on the Thames, which differs slightly from dinary management. The foundation or bed plate of the engine is ed of a strong cast-iron frame, extending across the vessel, and divided ee compartments; the two side ones being occupied by the cylinders, and tral one *a* forming the condenser; *b* is one of the cylinders, which is sus upon hollow axes or gudgeons, working in bearings attached to the te; *c c* are wrought-iron pillars, supporting the top frame *d*, that the bearing of the main shaft, which is formed into three cranks, to one h, *e*, the piston-rod *f* of the steam cylinder *b* is connected, whilst the one, *g*, works the air-pump *h* by the medium of the connecting rod *i*. am from the boiler enters by the gudgeon which is nearest the vessel's



d arrives at the slide-case *k* by the hollow passage or belt *m*. By the ve the steam is admitted to the cylinder, and discharged from the same, ing off by the midship gudgeon *n*, which forms the eduction passage, the condenser; *o* is the hot well, and *p* the waste water-pipe. cipal difference between the arrangement described and Mr. Penn's arrangement, is that in the latter the air-pump stands vertically the two engines, and that the slide valve case is placed at the the engine, that is to say, midway between the two gudgeons. We nclude our account of the varieties in the form of marine engines by different engineers, by a description of a rotatory engine recently by Mr. Peter Borrie, and which, we believe, has been applied to vessels.

's Rotatory Engine.—The accompanying engraving is a transverse sec- his engine through the centre of the cylinder. At *a* is the foundation which all the parts of the engine are directly or indirectly attached; external cylinder fixed to the foundation plate; *c* is a small cylinder, re- within the external one, on a shaft *d*, whose centre is placed so far above he external cylinder, that their circumferences may touch one another

at the upper point h^1; and the space between them thus gradually increases from h^1 to the lower point h^2. The shaft *d* passes through steam-tight stuffing-boxes in the cylinder ends, and revolves in bearings in the frames, which are firmly bolted to the foundation plate, and stayed to the cylinder; *e e* are two sliding pistons, consisting each of two arms, connected together by four rods passing over the shaft. Their breadth is equal to that of the outer cylinder and their joint length over their extremities is necessarily somewhat less than



its diameter, owing to the eccentricity of the revolving cylinder. These pistons slide freely at right angles to one another, through passages made in the circumference of the revolving cylinder, their sliding motion being caused by the pressure of one of their extremities on the ascending side of the outer cylinder (whichever side that may be); and the eccentricity of the revolving cylinder through which they slide. As their length is always slightly varying during the course of a revolution, the difference is made up by metallic packing placed

between the two thicknesses of plates, of which the arms of the pistons are composed. This packing is pressed by springs towards the sides and circumference of the outer cylinder, as will be readily understood by reference to the figure. In the passages in the inner cylinder, through which the piston slides, there are also metallic packings, which are pressed on the flat surfaces of the pistons by springs, and prevent the steam passing to the interior. There are, besides, two steel rollers at the inside of the packings, which are pressed up to the flat sides of the pistons by screws, for the purpose of diminishing the friction of their sliding motion; but these rollers are not necessary, except in large engines. The rim of the inner cylinder is made to project into metallic packing-boxes in the cylinder ends, whereby the steam is entirely prevented from passing into the interior of the inner cylinder. A packing-box is also placed at the point of contact to prevent the steam passing to either side. From what has been stated, it will be perfectly understood, that the steam only acts on the projecting part of the sliding pistons between the inner and outer cylinders. The steam, in coming from the boiler through the steam pipe *f*, has first to pass the slide *g*, which is worked by the handle *h*. After passing that slide, it enters the steam-tight jacket *j*, the bottom of which is the slide face, having the four cylinder ports *k l m* and *n*, and the eduction port *q* on it. A slide *o*, worked by a handle *p*, passes over these ports for the purpose of reversing the motion of the engine; in this slide there are two ports, o^1 and o^2. In the position in which the slide is shown in the engraving, the port o^2 is open to the steam port *l*, the port *n* is closed, and the two ports *m* and *k* are open to the eduction port *q*; so that when the slide is in this position, the engine will necessarily move in the direction indicated by the arrows. Now, by moving the slide along until the port o^1 is above the steam port *k*, then the port *m* will be closed, and *m* and *l* open to the eduction, so that the steam will act at the opposite side of the cylinder, and consequently the motion be reversed. It will here be observed that the lower cylinder ports *m* and *n* are never used for admitting steam, but only for leading off the used steam. The object in placing them so low in the cylinder is to allow the vacuum to act upon the pistons sooner. It must be kept in mind, therefore, that in whatever direction the shaft revolves, the steam is always admitted at one of the upper ports *k* or *l*, and the used steam let off at its opposite lower ports. All the ports where they lead into the cylinder are divided by bridges placed diagonally across them, so that the pistons may pass freely over them. From the relative position of the two cylinders, and the distance between their circumferences gradually increasing from contact at the upper point h^1 to the greatest distance at the lower point h^2 (which in this case is $\frac{1}{6}$ of the diameter of the external cylinder, but may be varied according to circumstances), it follows that in whatever direction the engine revolves, the area of that part of the pistons which is acted on by steam and vacuum gradually increases, so that the principle of expansion is carried out to its full extent without the aid of expansion valves and gear. The steam passing through the eduction passage *q* is conducted by the eduction pipe *r* to the condenser *s*; *t* is the injection slide placed at the lower end of the eduction pipe, and conducting the water up the pipe, so as to act fully on the steam in passing downwards; it is worked by a lever and rod, connected to the handle *u*, which is placed in proximity with the other starting handles *h* and *p*. The air-pump is a double-acting one. It has a metallic packed piston, which is worked from the main shaft by a crank and connecting rod; and the piston-rod is kept parallel by two slide guides bolted on the air-pump cover. The pumps are worked from the main shaft by an eccentric, connected by a rod and lever to a rocking shaft *d*, on which are keyed two levers, which are connected by rods to the bilge and feed-pumps. The latter has its valve chest *j* bolted on the hot well.

Condensation.—The means adopted for the condensation of the steam is almost universally by the injection of cold water into the condenser, as in land engines. But for the purposes of steam navigation, this method is attended by several serious evils, which we shall briefly notice. In the first place, the water being generally strongly impregnated with earthy or saline matter, and

the steam consisting of pure water only, this extraneous matter continues to accumulate in the boilers, and at length to form incrustations, which if not removed, would eventually fill the boiler. To prevent this occurring, several methods are resorted to (some of which we shall notice), but none are completely successful, and all are attended with some objection. Another evil attendant upon this system of condensation when applied to marine engines is that, as the supply of water to the boilers cannot be regulated by self-adjusting means, as in land engines, but must depend upon the care of the attendants, the fire-box and flues are liable to be burnt through in the event of the smallest inattention. Great care also is required in regulating the injection flow of water, for the vacuum causes the water to enter the condenser as fast when the engines are moving slowly, as when going at a great speed; and as it is exceedingly difficult to regulate the injection exactly to the irregularities in the speed of the engine, there is the risk of diminishing the power of the engines by admitting too small a quantity of water, or of choking the condenser and air-pump by an excess, which is frequently the occasion of serious accidents. The plan most commonly resorted to for preventing the deposition of earthy matter in the boiler, is to discharge a portion of the water from time to time (technically called "blowing out"), replacing it with water from the hot-well, with the view to prevent the water becoming saturated. Mr. Seaward has contrived an ingenious and extremely simple plan to guide the men in the performance of this operation. In the glass gauges, attached to the boiler to show the height of the water, are two glass bulbs of different specific gravities; when the water in the boiler approaches within a certain distance of the point of saturation, the heaviest bulb rises to the surface, whereupon the engineer should blow out water from the boiler, replacing it with water from the hot well, until the lightest bulb sinks. This contrivance is doubtless of great utility, as it enables the engineer to conduct the "blowing out" process with much greater precision than he could otherwise do. Mr. Seaward's apparatus for this purpose is shown in the annexed cut. At *a* is the glass gauge, chiefly inclosed in a metallic case *b*, and connected by the pipes and cocks *c c* with the boiler *d*. At *e* and *f* are screwed plugs having vertical stems proceeding from them, which enter the ends of the glass tube; *g* and *h* represent the two glass balls, the lower one of which, being the heaviest, is shown as resting upon the top of the lower stem, while the upper one floats on the liquid. The process is, however, still dependent upon the attention of the engineer, and, therefore, liable to be neglected. To obviate this Messrs. Maudslay and Field, instead of periodically blowing out the water, maintain a constant stream of water through the boilers, by means of a small pump, worked by the engines, and so proportioned as to draw from the lowest part of the boiler, at each stroke, as much salt as is deposited in the boiler by the steam consumed in that stroke. But the operation of blowing off, in whatever way it is effected, is seldom completely effectual. It also causes a great waste of fuel by expelling from the boilers such a large quantity of water at the boiling point.

These and some minor objections to the system of condensing by injection, becoming more sensibly felt as steam navigation advanced, have caused numerous attempts to condense the steam without injection, by bringing it in contact with metallic surfaces, surrounded by cold water; and the system has at length been brought to such perfection, as scarcely to admit of further improvement. Some of the arrangements for this purpose, which have been put in practice, we shall now proceed to notice.

In 1822 Mr. M. I. Brunel obtained a patent for various improvements in marine engines; one of which improvements consisted in a method of condensing

…eam without injection; with the view of keeping the water in the boiler …ntly fresh, and thus preventing the corrosion and incrustation which the …ea water occasions. The condenser consisted of a peculiar combination …es as represented by *Fig.* 1, which is a vertical section of the apparatus. …re a horizontal row of pipes, which the inventor calls "mains;" each of …mains has on the upper side a row of sockets, and from each socket rises …ster of copper pipes *b b*, of small diameter. These pipes are closed at the … ends, but open at the lower, which are inserted in holes in a sort of … fitted to the sockets on the mains, and secured thereto by a long screw-…, which passes down the centre pipe of each cluster, and is screwed into …ain, as shown in *Fig.* 2, which is a section of one of the clusters on a … scale. The mains and small pipes are placed in a cistern, through which

…g. 1.

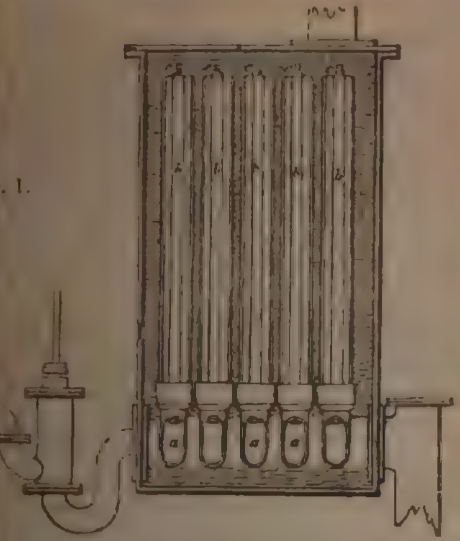
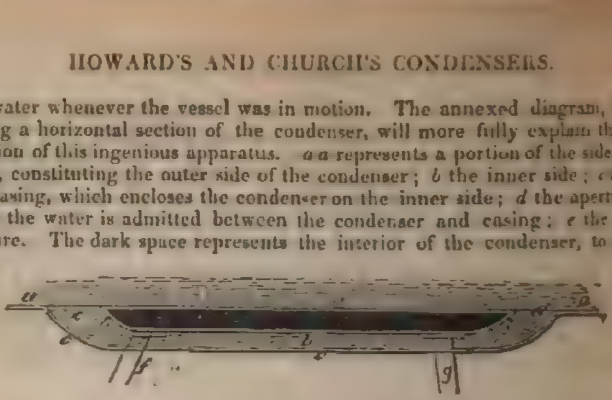


Fig. 2

…ent of cold water is maintained by a pump or other suitable means. The …from the engines enters the mains *a* by the pipe *d*, and ascending the …pipes *b b*, is condensed and restored to the form of water, which falling to …ttom of the mains, is withdrawn by a small force pump *e*, and returned to …iler. We are not aware that this apparatus has been tried, but we think, …rom the want of an air-pump, and from there being no thorough draft …h the small pipes, it would be difficult to discharge the air from …, which would, therefore, prevent a good vacuum being obtained, and …ally obstruct the condensation of the steam.

…ongst the first to put in practice this system of condensation in steam vessels …Mr. D. Napier, of Glasgow, who made trial of various arrangements of cool-…rfaces, and if he did not completely succeed in removing the evils com-…d of, he at least greatly reduced the amount of them. The arrangement …e adopted in a small iron vessel, called the *Kilmun*, deserves notice from its … simplicity. The condensers consisted of a shallow iron casing, on each side …engine-room, built upon the internal surface of the vessel, which thus con-… the outer side of the condenser. The inner side was covered by an iron … which communicated with the water outside by two large apertures in the …, one at the fore part of the condenser, and the other at the after part. …ace between the condenser and the casing being sufficient to allow a free …tion of the water, the condenser was exposed on each side to a current of

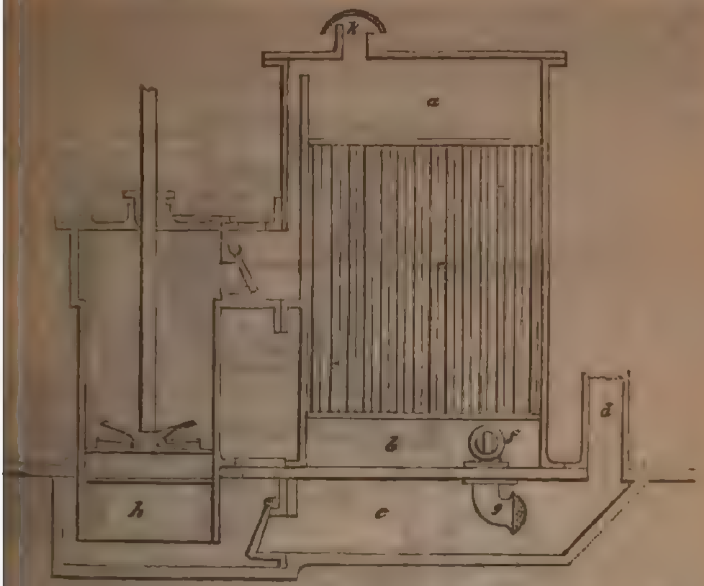
cold water whenever the vessel was in motion. The annexed diagram, representing a horizontal section of the condenser, will more fully explain the construction of this ingenious apparatus. *a a* represents a portion of the side of the vessel, constituting the outer side of the condenser; *b* the inner side; *c* a sheet iron casing, which encloses the condenser on the inner side; *d* the aperture by which the water is admitted between the condenser and casing; *e* the outlet aperture. The dark space represents the interior of the condenser, to which



the steam is conveyed from the slide case by the pipe *f*, attached to the top; and *g* is a pipe leading from the bottom of the condenser to the air-pump, by which the water and uncondensed vapour are withdrawn. Mr. Howard, of the King and Queen Iron-works, Rotherhithe, endeavoured to combine condensation by injection with surface condensation. The condenser consisted of a cylinder of copper, communicating with the eduction passage, and enclosed within another vessel, through which a current of cold water was maintained by means of pumps worked by the engine. Within the annular space between the two vessels was placed a worm of thin copper, the upper end of which was connected to a rose head within the condenser, and the lower end of which was connected to a small force-pump, which drew from the lower part of the condenser. The worm being filled with fresh water previous to setting the engine to work, at each stroke of the engine a portion of this water was injected into the condenser amidst the eduction steam, which thereby became condensed; and a portion of the water resulting therefrom was returned to the refrigerating worm by the force-pump, and the remainder forced into the boiler by the feed-pump. This plan of condensation was tried on board a government vessel, as also in two other vessels constructed by Mr. Howard, and, we believe, with satisfactory results: but as it formed only an accessory to Mr. Howard's "Vapour Engine," which proved a failure, it shared the rejection of the latter.

Some years subsequently, Dr. Church obtained a patent for a method of condensation, which was the same in principle, although the arrangements were somewhat different. The opposite figure represents a section of the apparatus. *a b c* is a vessel called the refrigerator. It is divided into three compartments placed over the condenser *e*, the upper one *a* being connected with the lower one *b* by a series of pipes of small diameter, which occupy the middle portion or cold water cistern *c*. During the operation of the engine a constant stream of cold water is maintained through this cistern. The chambers *a* and *b* being previously filled with distilled water, upon the admission of the steam from the engines into the condenser *e* by the pipe *d*, the injection-cock *f* is opened, and the injection water is distributed in a shower amidst the steam by the rose *g*, by which the steam is instantly condensed, and the water resulting from the condensation, together with the injection water, is drawn off by the air-pump, and delivered into the compartment *a*, to be cooled down again by descending through the refrigerating pipes *c*. On the top of the chamber *a* is a small open pipe for the escape of any air given out by the water.

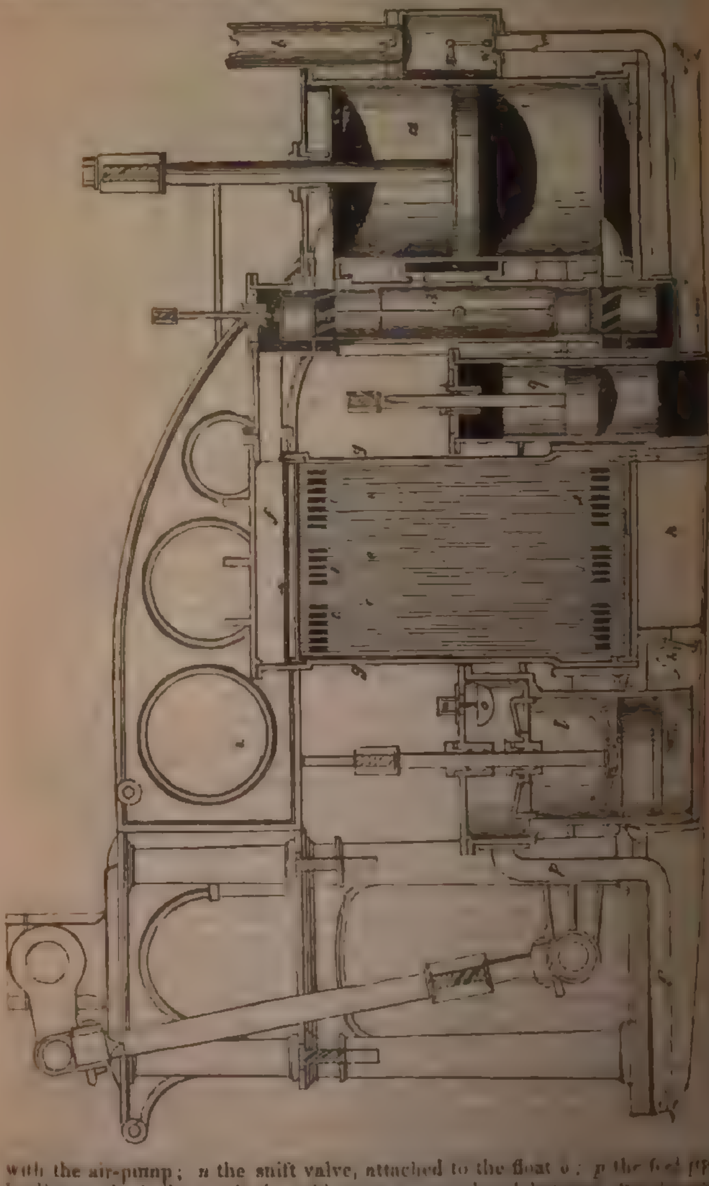
But no person has contributed so much to the introduction of this system of condensation as Mr. S. Hall of Basford, by his various contrivances to meet all the exigencies of the case, by his improvements in the construction of the apparatus, and by his unwearied exertions to demonstrate the superiority of the system, and to procure its general adoption. The following description will serve to give a general idea of his arrangements. The condenser consists of a cast-iron vessel, divided into three compartments by two horizontal plates. Into these plates are secured the ends of a vast number of copper tubes of small diameter, which form a communication between the upper and lower chambers,



compartments, of the condenser. Through the middle compartment, or water cistern, a stream of cold water is maintained by a double-acting p. The upper chamber communicates with the eduction passage, and the er with the air-pump. The steam from the eduction pipe entering the er chamber, is instantly dispersed through the condensing tubes; and by contact with their cold surfaces, is reduced into water, and falls in a shower e lower compartment, from which it is drawn, together with the air and ondensed vapour, by the air-pump. The air-pump delivers the water into ot well, which is closed at top, so that the upper part constitutes an air l, and the elasticity of the compressed air forces the water into the boiler, ugh a pipe proceeding from the lower part of the hot well to the feed valves cks on the face of the boiler. On the top of the hot well is placed a snift e, to maintain the water in the hot well at a certain height, so as to prevent air from entering the boiler along with the water. The whole of the steam the cylinder is condensed, the water returned to the boiler; but there is s a loss of water to a greater or less extent by leakage of the boilers, and escape of steam at the joints, and at the safety valve; the water in the s would, therefore, in time, be reduced below the proper level, unless s were taken to replace the quantity of water so lost. To meet this diffi-, a small vessel, called a "still," is inserted in the top of the boiler, and ected by a pipe and cock with the upper chamber of the condenser. This is charged with sea water, and when it is perceived that the water has e lower in the boiler, the cock is opened; and a communication being established with the condenser, a partial vacuum is formed in the still. causes the water to boil rapidly at a much lower temperature than it would wise; and the steam rushing into the condenser, is condensed along with eam from the cylinder. The additional water thus obtained is delivered e boiler by the action of the air-pump.

e annexed engraving represents, with some slight alterations, the arrange- adopted in a pair of engines constructed by Messrs. Hall, of Dartford, for the *force* steam packet. We select it as the most perfect which we have seen, because all the parts are distinctly shown. At *a* is the steam cylinder; *b* the

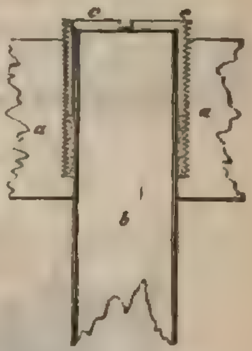
steam pipe; *c* a belt or channel surrounding the cylinder, and conveying the steam to the slide valve chest *d*; *f* is the upper chamber of the condenser; *g* the cold water cistern, in which the condensing tubes *e e* are situated; *h* the lower chamber of the condenser; *k* the foot valve; *l* the air pump; *m* the hot well, cast in one



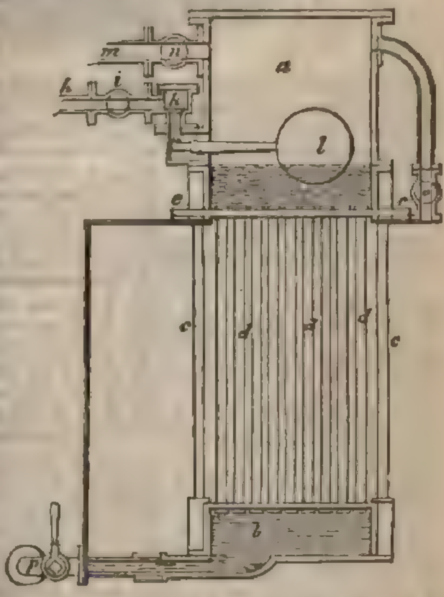
with the air-pump; *n* the snift valve, attached to the float *o*; *p* the feed pipe leading to the boiler; *q* is the cold water pump, placed between the [illegible] and the condenser; *r* the cold water supply pipe; the water is conveyed from the pump to the condenser by a channel cast on the foundation plate of the

engine and enters the condenser by the apertures *s s*; *t t* are outlet passages by which it is discharged into the sea; *v* is the throttle valve, and *w* the blow-through valve; *x* in the upper chamber of the condenser, is the distributing plate; and *y* the pipe leading to the distilling vessel. The axis of the side levers is not carried through the condenser, as is usual; but each lever plays upon a stout pin, firmly keyed into a massive block, or pedestal, cast on the foundation plate.

The figure in the margin shows the mode of fastening the condensing tubes; *a* is a portion of the upper plate of the condenser, made of brass or cast iron, and having holes formed in it to receive the ends of the tubes, a portion of one of which *b* is shown of the full size. These holes are to the depth of about half an inch, made of a rather greater diameter than the tubes, and are tapped to receive a screwed ring or ferule *c*; the end of the tube being inserted in the hole, a ring of soft tape is slipped over the end of the tube and screwed firmly down into the hole in the plate, so as to press it into close contact with the surface of the tube; by which means a joint is formed perfectly steam and water-tight; and which yet allows for the expansion and contraction of the metal.



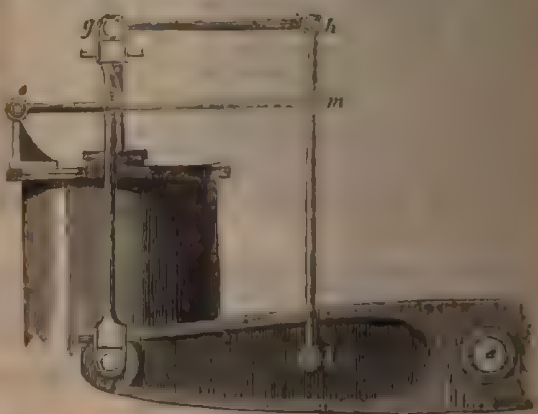
The annexed figure represents the distilling apparatus. At *a* is a cast-iron vessel bolted down over an aperture in the top of the boiler, and having a vessel *b* connected to it by rods *c c*. A series of brass or copper tubes *d d* connects the interior of the two vessels. The lower chamber, the tubes *d d*, and a portion of the upper chamber, contain sea water, which enters by the pipe *h*, connected with the cold water chamber of the condenser; *k* is a valve governed by a float *l*, by which the water is maintained at the proper level. From the upper part of the vessel *a*, a pipe *m*, furnished with a stop-cock *n*, proceeds to the upper chamber of the condenser. When the attendant perceives the water in the boiler beginning to fall, he opens the cock *n*, and the steam from the water in the still rushes into the upper chamber, and is condensed along with the steam from the engines; and the water resulting is forced into the boilers by the air-pump. When the water in the boiler is by this means restored to its proper level, the cock *n* is shut, and the operation ceases. When, from the water becoming saturated, it is required to "blow out" the still, the cock *n*, and a cock *i*, on the pipe *h*, are shut; and steam is admitted from the boiler into the upper vessel, by opening the cock *o* and the cock *p*, which connects the lower part of the still with a discharge-pipe



passing through the ship's side, and the water and sediment are driven out, after which, by reversing the position of all the cocks, the still is recharged with water from the cold water chamber of the condenser.

Mr. Hall's invention has been extensively adopted by the Admiralty, the East India Company, and various other companies; as well as private individuals. The *Sirius* of 320 horse-power, fitted with Mr. Hall's condenser, was the first steam vessel which crossed the Atlantic from this country.

Parallel Motion.—The parallel motion commonly employed in marine engines, working with side beams, is exactly similar in principle to that employed in land engines; but owing to the parts being inverted, it appears different. It is represented in the annexed cut.

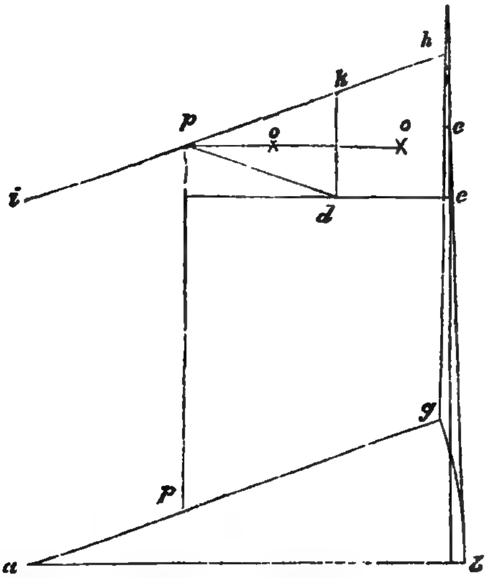


The radius shaft is usually worked by a single link, or side rod, which is attached to that radius bar and side beam which is next the vessel's side, in order to leave more space between the two engines for working the hand gear.

In constructing marine engines, it is occasionally required, that the centre of the radius rod shall be placed in some particular point; and it then becomes necessary to determine the length of the radius bar and of the parallel bar. This is usually ascertained by repeated trials with rods of different lengths, for want of a correct rule for readily determining it: we therefore give the following, which, we believe, has not before been published.

Let $a\,b$ represent the beam at its horizontal position, c the centre of the cross head of the piston-rod, and $c\,b$ the side rod by which it is connected to the end b of the beam $a\,b$; and let it be required that the centre of the radius bar shall be in the point d; then as the parallel bar is always parallel to the beam, and as at the horizontal position of the beam the parallel bar and radius bar will coincide or lie in the same horizontal plane, draw the line $d\,e$ parallel to $a\,b$, and it will represent the position of the parallel bar and radius bar in this position of the beam; and e will be the point at which the parallel bar is attached to the side rod; and $e\,d$ will be the difference between the length of the parallel bar, and that of the radius bar. Then through the point c draw the vertical line $c\,f$, to represent the path of the piston-rod, and draw $a\,g$ in the highest position of the beam, making $a\,g$ equal to $a\,b$, then from g with the length $b\,c$ intersect the line $c\,f$ in f, and draw the line $f\,g$, upon which lay off the distance $b\,e$ from g to h, then draw $h\,i$ of an indefinite length and parallel to $a\,g$, and on it lay off $h\,k$ equal to $d\,e$, the difference between the lengths of the radius bar and parallel bar; then, as the remaining portion of the parallel bar will be equal to the radius bar, and the two bars are connected at their extremity; if we draw the line $k\,d$, they will form with it an isosceles triangle

t of which will be at the point of junction of the two bars; therefore, he apex, upon *k* and *d* as centres, with any distance in the compasses arcs cutting in *o o*, through which points draw *o p*, cutting *h i* in *p*;



r *d p* and it will be the length of the radius bar; and *h p* will be the the parallel bar. Then upon *g a* set off *g r*=*h p* and draw *p r*, and present the back link, and *r* the point at which it is attached to the

ing *Motion*.—In steam vessels it frequently becomes necessary to ie engines suddenly, and sometimes to run a considerable distance by sed motion. It therefore becomes indispensable that the engine should ranged as to be completely self-acting whilst running in either

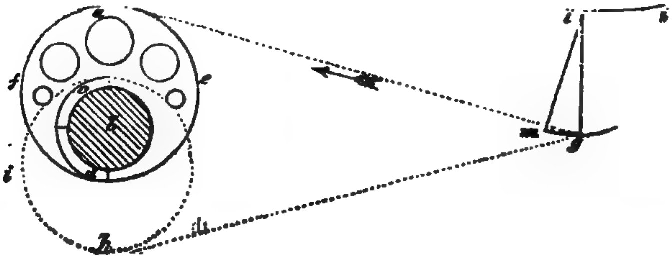
case of engines fitted with valves worked by a plug-rod and tappets, necessary to reverse the position of the valves by hand, and when the returned past the line of centres, the plug-rod will continue to work s, as before.

s plan of working the valves is chiefly confined to pumping engines. e engines the valves are almost universally moved by a cam or eccen- upon the shaft; whereby the motion is rendered much smoother, from concussion; but as the motion of the eccentric is reversed with e motion of the shaft, the reversed action of the eccentric would valve to move in the wrong direction unless some provision were he contrary, as will be more clearly seen in the following diagram. itric may be considered as a crank whose length is equal to the ty of the eccentric disk; let *a b* represent the position of the eccen- i the piston is commencing its ascending stroke, at which time we se that the valve lever *e f* should be depressed, or move in the *f g*; if the eccentric be carried round by the shaft in the direction ccentric rod *b h*, acting upon the lever *e h*, will depress the lever *e f*

as required. But if the motion of the shaft be reversed, the eccentric, moving in the direction *b d*, will thrust the lever *e h* towards *k* and raise the lever *e g* to the position *f l*. Some arrangement it will therefore be seen is necessary, to cause the eccentric always to move the valves in the same direction, at any

given position of the piston; whether the shaft be revolving forwards or backwards.

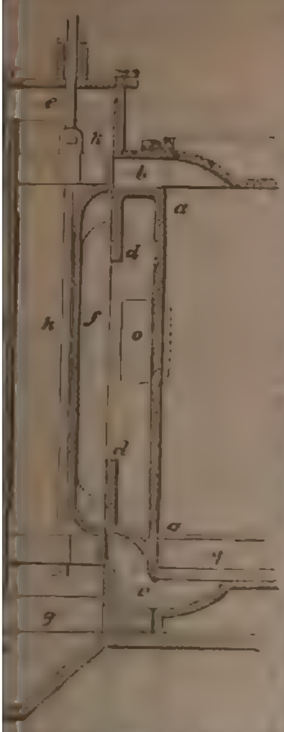
One of the methods employed for effecting this, is to fix two eccentrics upon the shaft, one adapted to the forward and the other to the backward motion of the shaft, each of which can be thrown into gear whilst the other is thrown out by the action of a lever. This method has the advantage of admitting the eccentric to be firmly keyed or staked to the shaft; it is however more expensive, and has the appearance of greater complexity, than the following method: which is therefore more generally practised. The eccentric *a* is not keyed to the shaft *b*, but is hung loose upon it with liberty of motion. On the side of the eccentric is cast a quadrantal piece *c*, and a similar piece *d* is fixed on the shaft, forming a species of clutch, the eccentric being carried round by the the piece *d* pressing on the piece *c*. Now supposing the shaft to be revolving in the direction *a e*, and it be required to reverse the motion; the eccentric rod is thrown out of gear, and the position of the valves reversed by hand; this causes the shaft to revolve in the direction of *a f*, and the piece *d* receding from



the piece *c*, the eccentric remains stationary until the shaft has made half a revolution, when the position of the eccentric is directly opposite to what it would have been had it travelled round with the shaft, and it will now be urged round in the direction *a f* by the piece *d* acting upon the other end of the piece *c*, and the eccentric rod being thrown into gear, will be pulled in the direction *g a*. If the motion of the shaft had not been reversed, the eccentric would have been in the position *b h*, revolving in the direction of the *h i*, and the eccentric rod *g h* would be pulled in the direction *g h;* the action therefore of the eccentric rod in both cases is to move the valve lever *g l* in the direction *g m*, and to depress the valve by the lever *l n*.

Another plan which is sometimes adopted, is, instead of reversing the position of the eccentric upon the shaft, to fix a double ended lever upon the valve shaft, and to connect the eccentric rod with the upper or lower end of the lever, according to the direction in which the paddle shaft is to revolve.

"long slide," invented by Mr. Murdoch, of the firm of Boulton and generally employed in marine engines. The annexed figure is a

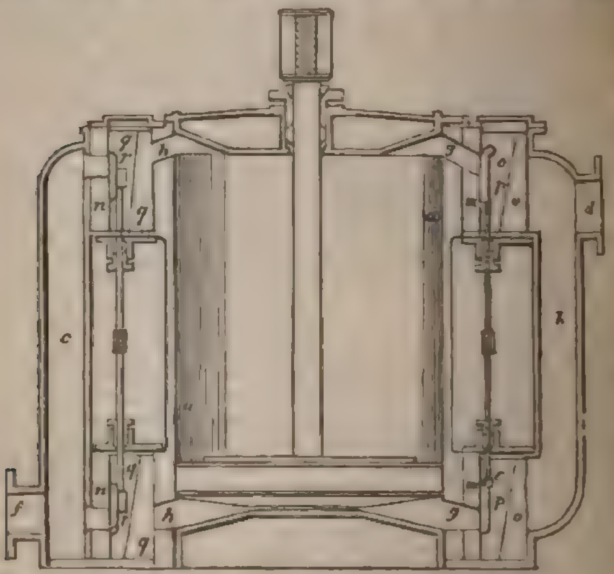


section of one of these slides. At *a a* is a portion of the steam cylinder; *b* the upper steam passage; *c* the lower steam passage; *d* a steam channel, cast upon the cylinder, between the necks *b* and *c*, to which is attached, by a flange, the slide case *e f g*, which is divided into three parts by the packing boxes *h h*, the middle part *f f* communicating with the steam channel *d*; and the upper part *e*, and the lower part *g*, communicating with each other by means of the hollow slide *k*: this slide is in its horizontal section of a semi-cylindrical figure; the flat part of the slide, and the face of the steam passage, are planed, and ground upon each other, so as to be steam-tight when in contact; and the slide is pressed against the face of the steam passage by semicircular blocks *m n*, which are faced with a broad soft gasket, and are pressed forward by screws at the back of them; *o* is the opening to which the steam pipe is attached, and *p* a channel, cast in the bed plate, and connecting the lower division *g* of the steam-chest, with the condenser; *q* a portion of the piston. In the sketch the piston is shown at the bottom of the cylinder, as having completed the downward stroke; and both the steam passages are closed by the slide *k*. That part of the cylinder above the piston, is filled with the steam which has depressed the and the middle part *f f* of the steam-chest is in free communication boiler, and is, therefore, filled with steam. In this state of things, if be depressed a distance equal to the depth of the steam passage *b* or *c*, from the middle part of the steam-chest will rush through the passage under side of the piston; and the steam above the piston will pass out passage *b*, and down through the central part of the slide *k*, and channel *p* into the condenser. In this species of slide valve it will be the slide is surrounded by steam, which, therefore, exerts no more upon it in one direction than another; and the only friction is that the packing at the back of the slide. The steam passages also are ter than with the D slide, so that there is much less loss of steam latter. The slide is usually either faced with gun-metal, or wholly of it; and for engines of large dimensions, instead of one long slide, tral tube, there are two short slides, which are connected together ; and the upper and lower divisions or vacuum spaces of the slide nnected by side pipes instead of the central tube.

lves, although very generally used in marine engines, are, how- to serious objections, from the necessity of using hemp packing at f the slide to keep it on the face. This packing requires to be and carefully adjusted; and should it be neglected, or ineffectually there will be a great loss in the active power of the engine. The e is, however, but seldom perfectly steam-tight, because if the screwed down so close as to prevent the escape of steam past it, becomes excessive: it therefore becomes necessary, for the easy

working of the valve, to admit of this escape, and consequent loss of power rather than contend with the very great friction which results when the rod is packed quite tight. Again, the quantity of hemp for packing, as well as tallow required to lubricate the same, is very great; and the slides are subject to considerable wear and tear, owing to the force with which they are pressed against the faces.

Seaward's Slide Valves.—The annexed engraving represents these valves as applied to a marine engine. *a a* is the steam cylinder, and *b* and *c* are the nozzles, either cast upon the cylinder, or firmly bolted to it; *b* is the steam nozzle, connected to the steam pipe by the neck *d*; and *c* is the eduction nozzle, communicating with the condenser by the neck or opening *f*. *g g* are the steam passages into the cylinder, and *h h* the eduction passages. In each nozzle are chambers to receive the cast-iron blocks *m m* and *n n*, which are ground to a perfectly plane surface on the face. The blocks *m m* have apertures, coinciding with the steam passages *g g* in the cylinder, and are firmly keyed against the cylinder by the keys *o o*; *p p* are the steam valves, which are flat plates of cast-iron; they are attached to the valve rods by a hinge-joint, the object of which is to allow the valve to swing off the face of the valve seats or blocks *m m*, to allow any water to escape which may find its way into the



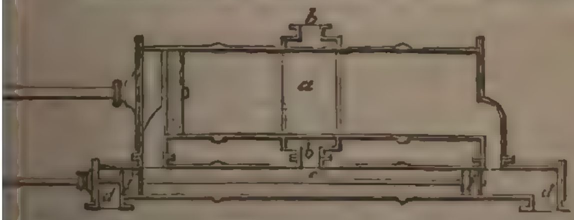
cylinder. The rods by which the valves are moved are connected, so as to cause the valves to move together. The blocks *n n* have apertures correspond-ing to the passages in the eduction nozzle, against which they are firmly keyed by the keys *q q*. The eduction valves *r r* are flat plates of cast-iron, similar to the steam valves: but as they are never required to leave the valve seat, they are fastened to the valve rod without a hinge-joint. Upon examination of the above arrangement, it will be seen that the steam valves are pressed to their seats by the steam in the steam nozzle, and the eduction valves are pressed against their seats by the steam in the cylinder. The lever by which the steam valves are moved is connected by a rod to that which works the eduction valves, so that the one set counterbalances the other.

Morgan's Conical Valves.—Mr. W. Morgan obtained a patent for an "Improved Construction of Conical Valves," which remedies the objection of

...to which they are subject, when large, in a very simple and ...ner. The eduction valves are so placed, that the steam in the ...pon their under surfaces, whilst the steam from the boiler presses ... surfaces of the steam valves; and the upper steam valve being ... the lower eduction valve, and the lower steam valve with the ... valve, the pressure upon the under surfaces of the eduction ... neutralizes the pressure upon the upper surface of the steam ...essure being merely equal to the difference between the areas of ...es; so that it requires but little force to move the largest valves.

The annexed sketch will help to convey an idea of these valves. *a* is the upper steam valve; *b* the lower steam valve, and *c* the steam pipe; *d* is the upper eduction valve, and *f* the eduction pipe. The lower compartment *g* of the upper valve box communicates with the upper steam passage of the cylinder; and the lower compartment *h* of the lower valve box communicates with the lower steam passage of the cylinder; the tail or spindle of the steam valve *a* passes through a stuffing box in the lower compartments of the upper valve box, and is connected by a coupling nut *k* with the spindle of the eduction valve *e*. The tail of the eduction valve *d*, in like manner, passes through the stuffing-box in the lower compartment of the upper valve box, and is connected by the coupling nut *l* with the lower steam valve *b*. The lifting rods *m* and *n* pass through stuffing-boxes in the covers of the valve boxes, and are wrought by means of two revolving cams, on a way shaft. By this arrangement the motion of each steam valve and its corresponding eduction valve is rendered simultaneous; and the pressure downwards upon the surface of the steam valves, is nearly counterbalanced by the upward pressure upon the eduction valves: a slight preponderance being given to the former, in order to keep the latter firmly to their seats when closed.

Piston Slide Valves.—Instead of the common semi-cylindrical slide valve, cylindrical, or piston slides are sometimes made use of, and possess this advantage over the former, that the packing being metallic, requires no attention, and that the friction ... The annexed cut shows a valve of this description. *a* is the ... *c* the slide case; *d d* eduction passages; *ff* the slide pistons, ...d with metallic packings. That portion of each end of the slide



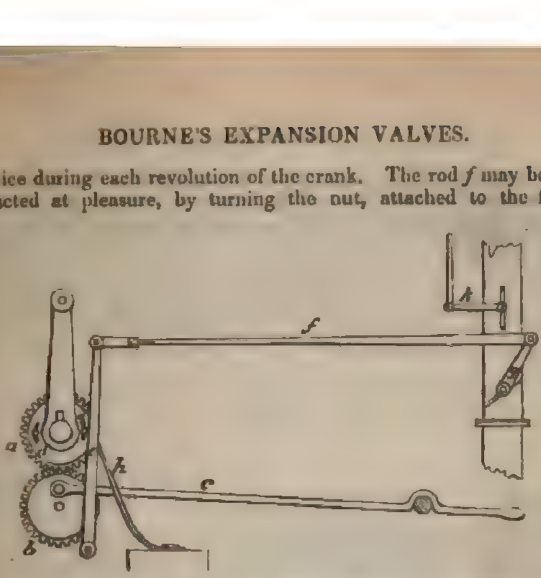
...these pistons work, is bored out very truly; and in order to ...ents of the packings to pass over the passages into the steam ... are cast in the passages, which prevent the segments from ...their places.

Expansion Valves.—Within these few years the application of the expansive action of steam has been gradually coming into use in marine engines, and with considerable advantage; but many circumstances tend to oppose its general adoption in this class of engines, and to prevent the realization of its advantages to their full extent. Foremost amongst these obstacles is the dread which is generally entertained of the use of high-pressure steam, on account of the supposed greater danger; and so long as the general opinion on this subject remains unchanged, steam-boat proprietors will fear to employ high-pressure steam, however much they may be convinced of its superior mechanical advantage. By cutting off the steam at a quarter of the stroke, the effect is nearly doubled, but to do this requires that the pressure of the steam should be nearly four times greater than for a non-expansive engine. Larger cylinders are likewise requisite, whilst in steam vessels it is an object to reduce the bulk and weight of the machinery as far as possible. The comparatively short length of stroke in marine engines is another obstacle, as scarcely allowing sufficient time for the admission of the steam; nor is the construction of the ordinary slide valve very well adapted to working expansively. In the Cornish engines which are mostly pumping engines, and single acting, the valves are of the conical kind, and are each moved separately by an exceedingly ingenious apparatus, but which is not at all adapted to the use of steam vessels. In marine engines the kind of valve which is generally employed, is, as already stated, the long slide valve; the slide is moved by an eccentric, with an alternately accelerated and retarded motion, but is never absolutely at rest. Some arrangement therefore is necessary to close the steam passage, and still keep the eduction passage open. The most common plan for effecting this is, to make the blank part of the slide, or that which covers the passages, longer than the passages themselves, and to give the slide a proportionably longer stroke; but the motion of the eccentric shuts off the steam too slowly, and the two passages cannot be opened exactly at the same time, at the reversal of the stroke, so that either the eduction passage is opened too soon, or the steam passage too late. Cams of various shapes have been substituted for the eccentric, with the view of opening and closing the passage more rapidly, and of allowing the slide to be at rest at certain points of the stroke; but they seldom work smoothly, and are generally soon destroyed by the violent concussions they experience in bringing the slide so quickly into motion from a state of rest. Some of these cams have also the defect of not being adapted to the reverse motion of the engines.

Another plan which is sometimes adopted is to construct the slide as for non-expansive engines, and to attach a separate valve between the steam pipe and the slide case. This valve is of a construction to move with little friction and consequently requires but little force to put it in motion. It is worked by a separate cam on the paddle shaft, which can be so arranged as to close the valve at any part of the stroke, within certain limits. Although rather more complex, this plan is decidedly superior to the others, in the precision of its action, and in the circumstances that the expansion can be varied, or the engine made to work at full pressure at pleasure.

Snodgrass's Expansion Apparatus.—The annexed cut represents Mr Snodgrass's method of working expansively, with the ordinary slide valve. Upon the paddle shaft, and at the back of the crank, is fixed a spur wheel *a*, which gives motion to another wheel *b*, of similar dimensions, and which revolves upon a stout pivot or stud. This latter wheel corresponds to the ordinary eccentric, and has on its face a pin, to which is connected the eccentric rod *c*, which moves the valve shaft. On the face of the wheel *a* are two pins, which carry the antifriction rollers *d d*, that act alternately against the perpendicular lever *e*, to the top of which is jointed a rod *f*, that is connected to the governor valve *g*, placed in the pipe which conveys the steam to the slide case; *h* is a spring acting on the back of the lever, to force the valve forwards as the rollers *d* on the wheel *a* retire; and thus by the alternate action of the spring, and of the rollers *d d*, the governor valve is opened and

closed twice during each revolution of the crank. The rod *f* may be elongated or contracted at pleasure, by turning the nut, attached to the fork which



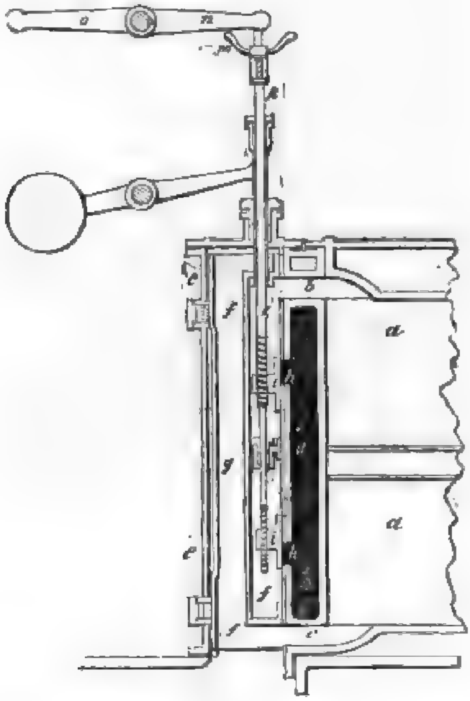
connects it to the lever *e*, and by this means the steam may be cut off at any portion of the stroke, and the remainder of the stroke be performed by its expansion; *k* is a throttle valve to be regulated by hand; it is connected by a rod to a lever under the command of the pilot.

When conical valves are employed in lieu of slide valves, and receive their motion from an eccentric on the paddle shaft, a separate valve, moved by a separate cam, is necessary to work the steam expansively. This additional valve and cam may, however, be dispensed with, if, instead of the rocking shaft, a revolving shaft be substituted, carrying a separate cam for each valve; which can thus be made to open and close at that period of the stroke which is required to produce the best effect. The revolving shaft is put in motion by the paddle shaft, by means of suitable gearing. By this mode of working the valves, the action is rendered as rapid as if raised by tappets, and the concussions of the latter mode are avoided.

Bourne's Expansion Valves.—This is an arrangement for cutting off the steam at any portion of the stroke, and for varying the quantity of steam admitted to the cylinder, without stopping the engine; for which in connexion with other improvements, Mr. Bourne of Dublin obtained a patent in 1838.

a a represents a section of a portion of the steam cylinder; *b* the upper, and *c* the lower steam passages; *d* the steam jacket or belt, *e e* the slide case connected at bottom with the condenser, and *f* a long D slide, by which the passages *b* and *c* are opened and closed in the usual way. That portion of the slide by which the steam is admitted to the passages, is divided into two parts by a partition *g*, which is faced and ground upon the face of the steam belt. The steam is admitted to the slide from the belt, by the apertures *h h*, to which are admitted the sliding valves *i i*; these valves are moved by a rod *k*, which passes through the rod of the D slide (made hollow for that purpose), and through a stuffing-box in the division *g* of the D slide. Upon this rod are cut two screws, one above and the other below the stuffing-box, which screws work in nuts on the back of the slides *i i*, and being one a right-handed, and the other a left-handed screw, upon turning the rod by means of the handle *m*, fixed on to its upper end, the valves are made to approach or recede from each other, according to the direction in which the rod is turned. The D slide is worked by the eccentric in the usual way, and opens and closes the two passages *b* and *c* at exactly the same time, but the rod *k* by which the slides *i i* are worked is connected to an arm *n* fixed on the shaft of the radius bar *o*, which governs the parallel motion of the engine, so that the D slide and the slides *i i* move independently of each other, and whilst the steam passages into the cylinder (*b* and *c*) remain open throughout the stroke, the steam passages into the slide (*h h*) can be closed at any portion of the stroke which may be decided

on. This is effected as follows: the depth of the apertures *h h* is equal the le of the stroke of the arm *n*, but the slides *i i* are so arranged upon the rod to contract them in proportion to the degree of expansion at which the st is to be worked; thus if it be required to cut off the steam at half str allowing it to expand through the remaining half, the slides *i i* are so set the rod *k* that each aperture alternately shall be but half open at the comme ment of the stroke, and as the slides begin to close with the commence of the stroke, the passages, *h h*, will be closed when the slides have made

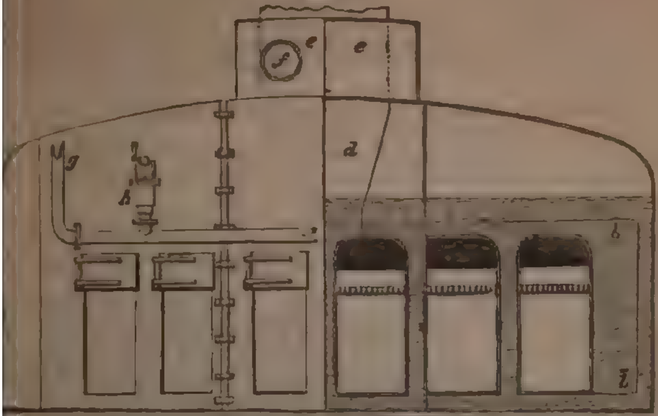


the stroke, as in the figure, and no more steam will be admitted to the cylin and the remainder of the stroke will be performed by the expansion of steam already admitted. If the steam is to be cut off at $\frac{1}{4}$ of the stroke, passages *h h* must open only $\frac{1}{4}$, and if it is desired to work at full pres throughout the stroke, the slides must be so arranged that the passages be fully open at the commencement of the stroke.

Boilers.—It having been found desirable in steam vessels to economize th utmost the space occupied by the apparatus, a material difference in the struction of the boilers becomes necessary from those used in land-eng in order to the economical combustion of the fuel; and in consequence of different arrangements, marine boilers are more complex, heavy, and co than land-boilers of similar power. In general, marine boilers are comp of an external shell or casing, with rectangular sides, stayed together by bars; and within the shell are contained the fireplaces or furnaces, and the for the passage of the flame and smoke, the flues being deep rectan channels, which, after making various turnings, unite in one common chi or funnel; the furnace, ash-pit, and flues, being entirely surrounded by w In order to maintain a considerable depth of water over the flues and furn

at the same time afford sufficient space for the accumulation of steam, an ...led compartment, called the "steam-chest," is formed for the purpose ... the top of the boiler, and the bulk of the boiler is occupied with water.

Fig. 1.



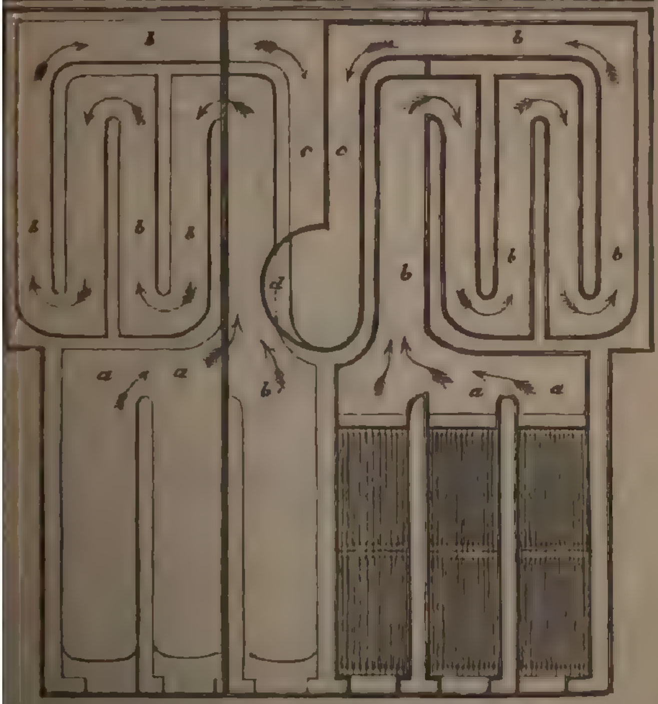


Fig. 2.

... boilers of large power, and especially in sea-going vessels, in order to ...t the water from accumulating on the lee side of the boiler, and leaving

the weathermost flues uncovered by water, the boiler is formed in two or three longitudinal compartments, with a free steam communication between each; or one or two divisions of plate-iron are formed within it, running from front to back, and extending from the bottom upwards, higher than the water line in the boiler. At the bottom of the boiler are pipes, passing through the vessel's sides, and furnished with stop-cocks, or valves, for "blowing off" the water from time to time, as it becomes saturated with salt; and there are apertures called mud-holes, closed by doors, for the purpose of raking out the mud or other deposits.

We proceed to give a few of the forms of boilers which are employed in steam vessels.

The engravings on the opposite page represent a boiler of 180 horse-power, constructed by Messrs. Fawcett of Liverpool.

From the very great extent of flue through which the smoke and heated air has to pass before it reaches the chimney, these boilers are found to raise steam very rapidly, and with a small consumption of fuel.

The one-half of *Fig.* 1 is a front elevation, and the other half is a vertical section of the boiler through the fire-places.

Fig. 2 shows a half plan of the flues, and a horizontal half section of the same above the fire-bars.

The boiler is composed of three separate parts, the sides of the middle boiler serving as a side to each of the side-boilers. At some distance above the water line, large apertures are cut in the sides of the middle boiler, to form a steam communication between the three compartments, and a water communication is established below by a pipe from each boiler opening into the blow-off main. Each boiler has two fire-places, and the flues *a a* of the side-boilers branch into the flues *b b* of the contiguous fire-place of the middle boiler, immediately at the back of the bridge; and, after taking the circuitous course shown in the plan by the arrows, they unite at the back of the boiler, and form one large flue *c*, from which the chimney *d* rises at about the middle of the length of the boiler. The flues are not divided horizontally, but extend the whole depth from *b* to *b*, as shown in the vertical section. Towards the fore part of the middle boiler is a steam-chest *e*, from which proceeds the main steam-pipe *f* which conveys the steam to the cylinders. *g* is the feed-pipe, and *h* one of the feed-valves.

Separate Elliptical Boilers.—Instead of building the boilers in two or three flat-sided divisions up to the water-line, and covering the whole with one slightly convex roof or top, many manufacturers prefer completely distinct boilers of an elliptical form, connected merely by pipes, forming the steam and water communications. This method has the advantage, that if either of the side-boilers should be by any accident rendered unserviceable, it may be shut off, and thus it would not impair the efficiency of the other two, provided that the steam communications should be each furnished with a stop-valve.

Elliptical boilers, variously arranged, are getting much into use in Scotland, especially on the Clyde. The annexed sketches represent the boilers of the *Sirius* steam-ship, constructed by Messrs. Wingate and Co. of Glasgow. *Fig.* 1 is a transverse section of the middle boiler and one of the side-boilers, and a front elevation of the other side-boiler. *Fig.* 2 is a longitudinal section of the middle boiler.

The three boilers are all of the same dimensions, and have each three fire-places *a a a*, as shown in the elevation of one of the side-boilers. From each fire-place a flue *b b* proceeds in a direct line to the back of the boiler, where it is curved upwards, and is returned, and forms an upper flue *c*, lying directly over the flue *b*, and extending to about midway of the boiler. Each of the three flues *c* opens into a transverse flue *d*, and the transverse flues *d* of the side-boilers communicate with the transverse flues of the centre boiler. *e* is the chimney, rising from the upper side of the transverse flue of the centre boiler, and passing through *g* the steam-chest of the same boiler; *h* and *i* are the steam-chests of the side boilers, and communicate with the steam-chest of the centre boiler, the former by the pipe *m*, and the latter by the pipe *n*.

bottom of each boiler is a pipe o, furnished with a cock, and branching the transverse main p, by which means the communication between the r spaces of any two of the boilers can be opened or cut off at pleasure; the steam main proceeding to the engines; r the safety-valve, upon the

Fig. 1.

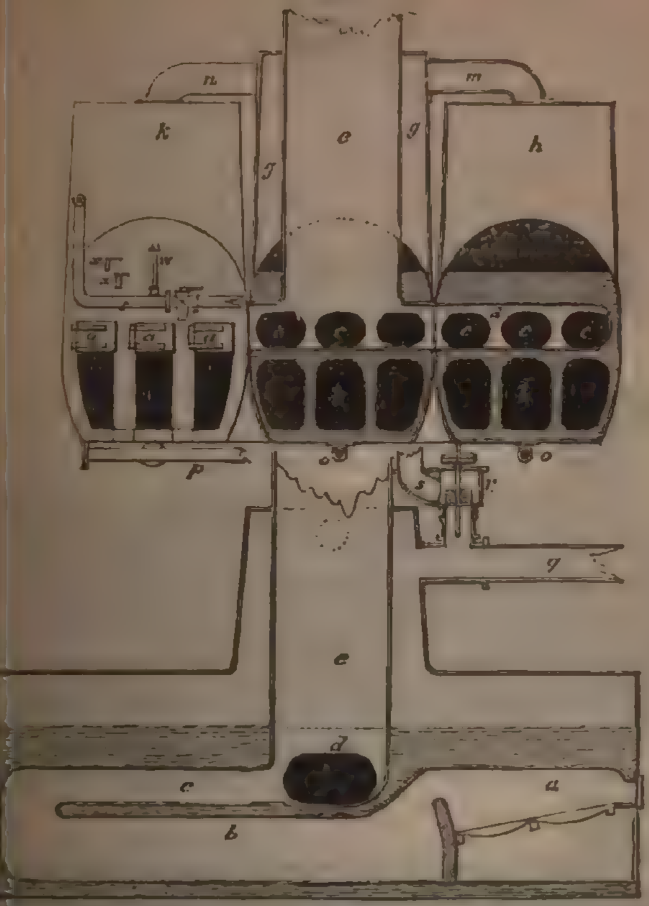


Fig. 2.

e of which are placed the weights; s the pipe for the escape of the steam has passed the safety-valve; t is the feed-pipe, fitted with stop-cocks; a glass gauge for showing the height of the water in the boiler; x x are -cocks for the same purpose.

United Kingdom" Boilers.—The annexed figures represent the boiler of the *Kingdom* steam-packet, the engines of which are of 200 horse-power, onstructed by Mr. D. Napier, of Glasgow.

. 1 is a front elevation; *Fig.* 2, a lateral elevation; and *Fig.* 3, a longi-l section. The boiler, which is of wrought iron, is 25 feet 6 inches gth, 19 feet in breadth, and 8 feet 6 inches in height. There are eight

rectangular tubes *b b* running lengthways of the boiler. The fire is placed in the upper part of each of these, upon the bars *c c* in the section. At the

Fig. 1.

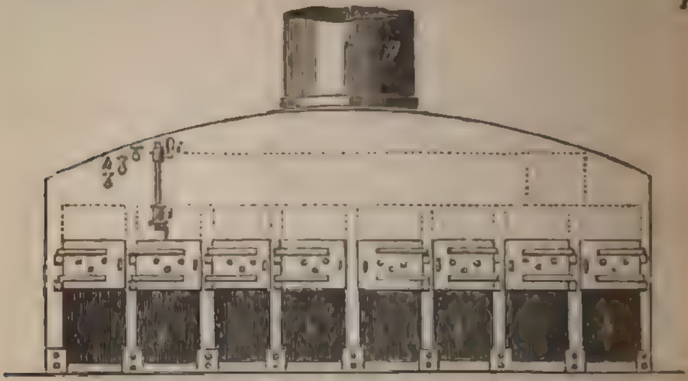


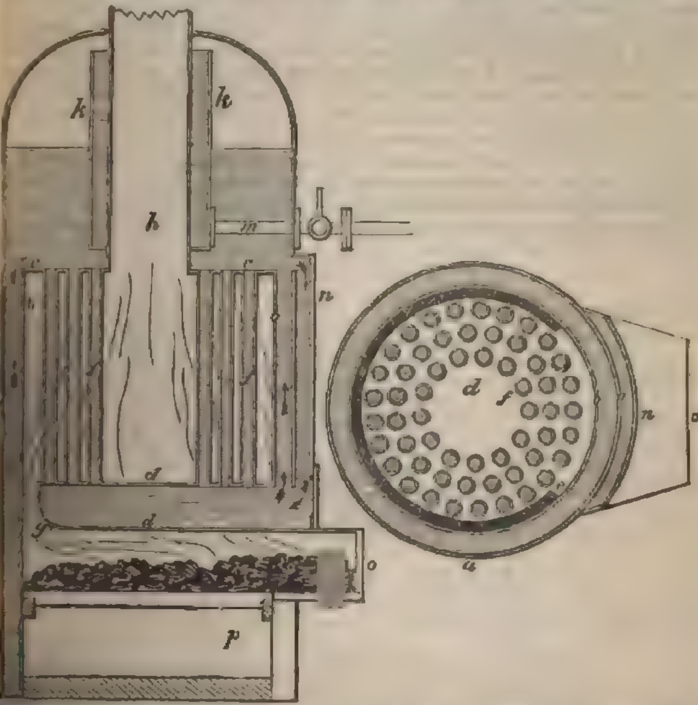
Fig. 2.

Fig. 3.

farther end of the tubes is a transverse one *d*, extending the whole breadth of the boiler, which communicates with every one of the tubes containing the fire

at each end of *d*. On the top, a return tube *e e* carries off the smoke and fire into another transverse tube *f*, out of the centre of which the chimney *g* rises. The cocks *h h h* are for ascertaining the height of water in the boiler. As an additional precaution, there are two cocks *i i*, which are placed, the one considerably above, and the other as much below, the assumed level of the water; these cocks communicate with a vertical glass tube *j*, of sufficient strength to endure the force of the steam. On the cocks *i i* being opened, water enters into the lower cock, and steam into the upper one; and the pressure being the same in the boiler, the water stands at the same level, and thereby indicates at all times whether it be too high or too low in the boiler.

Recently, steam of high pressure having come somewhat extensively into use, in order to carry out as far as possible the expansive system of action, a corresponding modification in the construction has become necessary, and tubular boilers, variously arranged, have been employed. The annexed figure



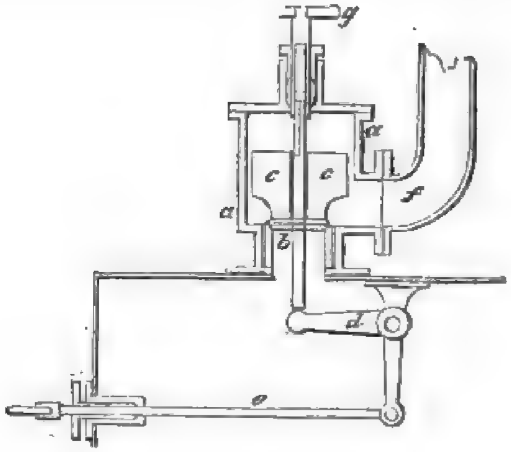
represents an arrangement for which Mr. D. Napier obtained a patent, and which he has introduced into several vessels under his management.

a a is a cylindrical chamber, with a dome top, constituting the outer shell, or outer casing of the boiler; and *b b* is a smaller cylinder, with a flat top *c*, placed concentrically within the chamber *a*, and constituting the fire-box, whilst the space included between the two cylinders forms the water-chamber. Within the fire-box, and on a level with the upper part of the fire-door, is a flat circular vessel *d*, which is connected to the annular part of the water-chamber by a neck *e*, and to the upper part of the chamber by several concentric rows of pipes *f f*. The vessel *d* is somewhat less in diameter than the fire-box, so that there is an annular space *g* between its circumference and that of the fire-box, which forms a flue or passage through which the smoke and heated gases from the furnace pass, and thence traversing the interstices between the pipes *f f*, escape by the chimney *h*, which rises from the roof of the fire-box, and passes

out through the dome of the boiler. In order to protect the chimney as as possible from the effects of the fire, that portion of it which is withi boiler is surrounded by a water casing *k*, which is open at top. The feed- for continuing the supply of the boiler enters this casing near the b by the feed-pipe *m*, and overflows at the top; and in order to maint free circulation, a wide channel *n* is formed on the outside of the c which, being farther removed from the fire-box than any portion o annular chamber, a descending current is maintained therein, whil ascending one takes place in the pipes and the annular water-chamb is indicated by the arrows. *o* is the fire-door, and *p* the ash-pit.

Safety Valves.—Various descriptions of safety valves are in use on steam vessels, some of which are of a very improper construction, being to be impeded in their action by design or by accident. For a safety val fulfil the purpose for which it is designed, it should be so arranged that th upon it cannot from any cause exceed that which the boilers have been c lated to sustain, and whilst the engineer should have the means of raisin valve, so as to ascertain from time to time that it is not set fast, he should no means of holding it down, or preventing its rising. In many vessels, ever, the valves are placed above deck, and are loaded by weights, either p directly on the spindle, or suspended from a steelyard lever acting upo spindle; in either case the load may be increased and too often is to a dangerous extent. In others, a more judicious arrangement prevails, the v being so situated as to be inaccessible to the engineer, who therefore ca increase the load beyond that which they were originally intended to carry

The annexed cut represents a section of a safety valve of this descriptio



a is the valve-box, *b* the valve, upon which is placed a cylindrical weight which nearly fills the box, there being merely sufficient space round at the c cumference to prevent rubbing, and sufficient space between the top of t weight and the cover to allow the valve to rise to the requisite height, and t cover is bolted down to the box. *d* is a bell-crank lever within the boiler, acti upon the lower end of the valve spindle; *e* is a rod connected to the lower e of the lever, and passing through a stuffing-box in the front of the boi Upon pulling out the rod *e*, the valve is raised by the lever, and the st escapes at the waste pipe *f*, and upon thrusting the rod in, the valve falls its weight. In order to guide the valve, and at the same time to afford means of turning it in its seat, the upper end of the spindle, which pa through the weight *c*, is made square, and enters a corresponding cavity in key *g*, which turns in a stuffing-box in the cover, the cavity being of suffic depth to allow the valve to rise.

SECTION IV.

THE CONSTRUCTION AND ARRANGEMENT OF THE PROPELLING MACHINERY.

Analysis of the various Plans for Propelling.—The ordinary or undershot Water-wheel—defects of Galloway's Cycloidal Paddle wheel.—Gemmel's Paddle-wheels.—Galloway's double oblique Wheels.—Buchanan's Parallel Float-wheels.—Oldham's vibrating Float-wheels.—Morgan's vibrating Float-wheel.—Dawson's radiating feathering Paddles.—Stead's Ditto.—Leeming's eccentric sliding Floats.—Endless chain propellers.—Spurgin's endless Chain-propeller.—Stevens's crank-action Propellers.—Nairne's collapsing Propellers.—Perkins's oblique sculling Wheel.—Linnaker's Propelling Pumps.—Busk's Hydraulic Propellers.—Ericsson's screw Propeller.—Hunt's propelling and steering Screw.—Canal Navigation.—Seaward's Spike wheel.—Saxton's differential warping Wheels.

In the present section we shall consider the means by which the power of steam is applied to the propelling of vessels. Numerous plans have been brought forward for this purpose, but they are all reducible to a few classes; the difference between those in each class being merely modifications of some particular principle. We shall therefore limit ourselves to a description of one or two examples from each class. In most of the various plans adopted or proposed for propelling vessels by steam, the motion is produced by one or other of the following means.

1. Wheels on the principle of the undershot water wheel, with fixed floats variously arranged.—Illustrated by the examples herein given of *Galloway's* and *Gemmel's* wheels.

2. Wheels with moveable floats turning on horizontal axles or spindles.—Illustrated by the inventions of *Buchanan*, *Oldham*, and *Morgan*.

3. Wheels with moveable floats turning on radiating axles or spindles.—Examples of which are produced in the inventions of *Dawson*, *Oldham*, and *Stead*.

4. Wheels with floats sliding along the arms, towards, and from the centre of the wheel.—Sufficiently illustrated by the invention of *Leeming*.

5. Ranges of paddles attached to endless chains.—Shown in the invention of *Spurgin*.

6. Ranges of paddles attached to cranks.—Illustrated by *Stevens's* invention.

7. Paddles which collapse during the return stroke, so as to offer less resistance at that time, commonly known as the duck's-foot apparatus.—An example of which is given in *Nairne's* invention.

8. Sculling.—Exhibited in *Perkins's* invention.

9. A stream of water expelled from the vessel, either by pumps or by the direct action of the stream, on the principle of Savery's engine.—An example of which is afforded in the invention of *Linnaker*.

10. By the reaction of the water, on the principle of Barker's mill.—Exhibited in the invention of *Busk*.

11. A water screw.—Illustrated by the invention of *Ericsson*.

Besides the above plans, which are applicable to steam navigation in general, there have been proposed for the navigation of canals and shallow rivers, some of which we shall notice.

Undershot Water Wheel.—Of all the plans of propelling, the undershot water wheel, with radiating floats attached to the arms of the wheel, is that which is most generally employed, on account of its extreme simplicity, its strength of construction and its little liability to derangement. The proportions most generally adopted are to make the diameter of the wheel equal to four times

the length of the stroke, and the depth of each paddle about one-eighth of the diameter. In steamers intended to ply chiefly on rivers, the width of the paddles is commonly about one half the diameter of the whole, but in sea-going steamers the breadth is commonly about one-fifth less.

Although the undershot water wheel is generally deemed superior upon the whole to any other apparatus for propelling steam vessels, it still possesses several defects, the chief of which are the waste of power caused by the oblique action of the floats, and the swell caused by the back water, especially in narrow and crowded rivers, where small boats and deeply laden barges are frequently swamped. The same cause also, more perhaps than any other, has opposed the adoption of steam in canal navigation, as the swell caused by the paddles has been found to destroy the banks rapidly.

These defects of the ordinary wheel, which are universally admitted to a certain extent, although their importance is differently estimated, have been felt from the commencement of steam navigation, and the attention of the mechanical world has been occupied to devise modifications of it, or substitutes for it, which shall be free from them. In fact, it has become a sort of mechanical hobby, and perhaps more patents have been taken out for improvements in propelling, than for any one subject, the steam engine only excepted.

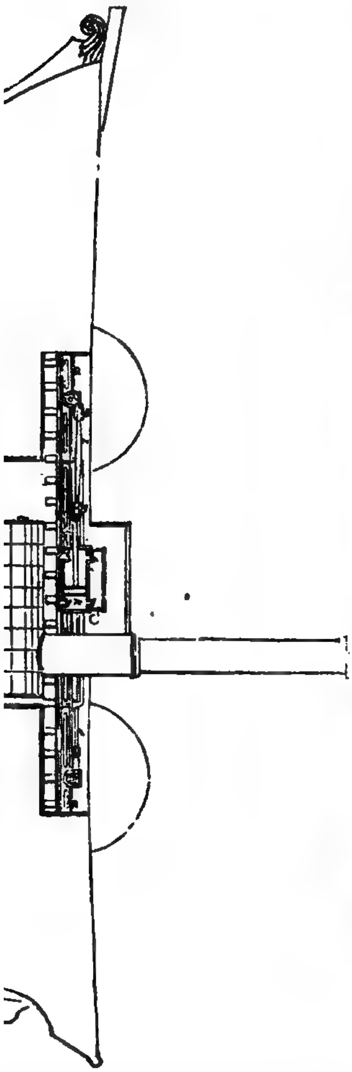
Galloway's Cycloidal Paddle-Wheel.—In 1835, Mr. Elijah Galloway obtained a patent for a paddle-wheel, which is free from many of the objections to which other inventions for the same object are liable. It is equally simple as the common wheel (of which it is in fact a modification), and is as little liable to derangement, and from the extensive adoption of it in steam vessels of all descriptions, we may infer that it possesses considerable advantages, having the whole depth of the float of one unbroken area; the floats are in divided portions, whereas the concussion on entering the water, and the amount of the back water, are greatly reduced.

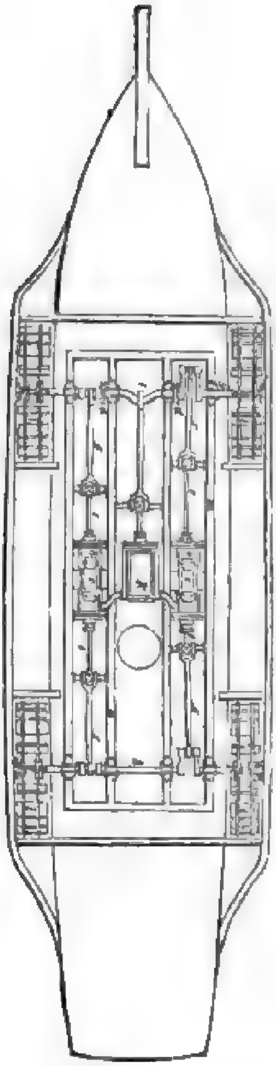
a a in the figure, which is a side elevation of the wheel, represents the circle, or course of the outer edges of the floats; and *b b* the circle bounding the inner edges of the floats; *g g g* are a series of portions of floats, which are set on curved lines, approximating to the cycloidal line *d f* at their outer edges, and are securely affixed to the paddle-wheel by screw-bolts and nuts or other means. Now it will be obvious if the paddle-wheel be supposed to be revolving in the direction of the arrow, and the vessel going at such speed as that her velocity is equal to that of the inner circle *b b*, then the bars constituting one paddle would enter the water at the point *f* or nearly so, and displace very little more water than that disturbed by the lowest bar. Thus the waste of power attendant on the common radial float board is obviated, and the concussion produced thereby almost entirely avoided.

Gemmel's Paddle-Wheels.—We have already noticed Mr. Gemmel's tow-boat in our second section. In the same patent (1837) he proposed to employ *two* pair of paddle-wheels of the ordinary construction to steam vessels generally, with a view to enable them to attain a speed adequate to the power of the engine employed, and that even when the breadth of the wheel is necessarily restricted, to enable the vessel to pass through narrow openings, such as the gates of canals, &c. One of his arrangements for these purposes is exhibited in the accompanying figures 1 and 2, the former being a longitudinal section.

vessel, with a side elevation of the machinery, and the latter a plan of
ie.

Fig. 1. *Fig.*2.

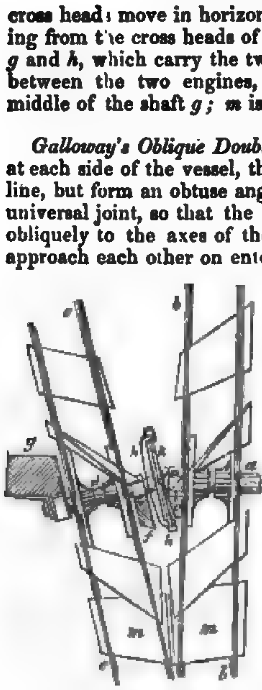




suitable metallic framing *a a a*, are fixed a pair of marine engines,
; horizontally; *b b* are the working cylinders, *c c* the slide-valve
d the eccentrics by which the valves are worked; but the rods are
to avoid confusion in the engraving; *e e e e* piston-rods, proceeding
ch side of the pistons, and working through stuffing-boxes in the two
f each cylinder. To maintain the parallelism of the piston-rods, their

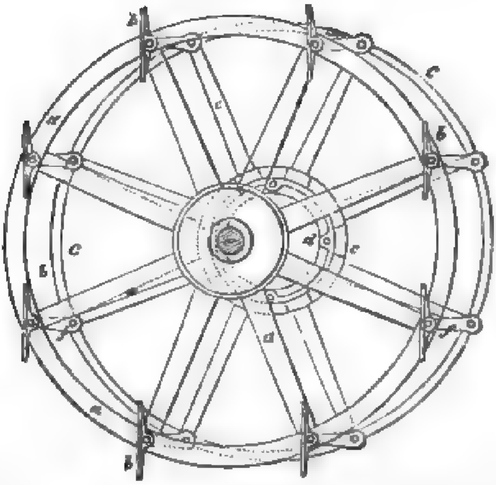
cross heads move in horizontal guides. *f f f f* are the connecting rods, proceeding from the cross heads of the piston-rods to the cranks upon the two shafts, *g* and *h*, which carry the two pairs of wheels *i i i i*. The air-pump *k* is placed between the two engines, and is worked by a short crank *l*, formed in the middle of the shaft *g*; *m* is the boiler, and *n* the chimney.

Galloway's Oblique Double Wheel.—In this invention two wheels are placed at each side of the vessel, the axes of which wheels do not lie in the same right line, but form an obtuse angle with each other. The axes are connected by a universal joint, so that the wheels revolve together, and the floats being set obliquely to the axes of the wheel, the descending floats in the two wheels approach each other on entering the water, so as to retain it between them, in the action of propelling, whilst the ascending floats as they leave the water gradually separate, so as to avoid lifting the water as they rise out of it.



The accompanying cut gives an end view of the wheels, with the descending or entering floats; *a* is the inner or driving shaft which carries the wheel, *b* the outer end of the shaft, turning in a plummer block on the spring beam *c*, *d* is the outer shaft carrying the wheel *e*, and working in bearings attached to the spring beams *f* and *g*; *h h* a cross arm keyed on to the inner end of the outer shaft *d*, and the extremities of which are connected by two drag links *k k*, to a similar cross arm on the outer end of the shaft *a*, thus constituting a universal joint, by which the motion of the shaft *d* is effected; *m m* are the descending floats, the ascending ones being omitted to avoid confusion.

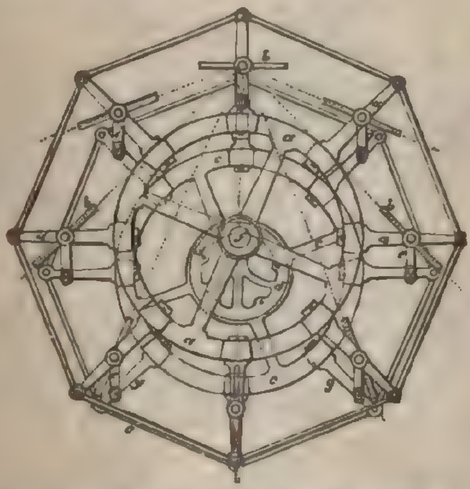
Buchanan's Parallel Float Wheel.—With the view to obviate the loss of power which has place in the ordinary wheel, owing to the oblique action of the radiating floats, Mr. Buchanan invented a wheel in which the whole of the paddles constantly preserve a vertical position during the entire revolution. The annexed figure is an elevation of Mr. Buchanan's wheel.



a a is the paddle-wheel, *b b* the floats attached to spindles working in the rims of the wheel; *c c* a guide wheel revolving on an eccentric disc or ring *d*,

fastened to the vessel's side; the main shaft *e* passes through the ring or disc: on to each of the spindles of the paddles is keyed a crank *f f*, the length of which is exactly equal to the distance between the centre of the paddle-wheel and the centre of the guide wheel, and in the guide wheel are a number of pins which work in the other end of the cranks. The diameter of the paddle-wheel from centre to centre of two opposite spindles being exactly equal to the diameter of the guide wheel at the centre of the pins, the guide wheel is drawn round by the cranks with the same velocity as the paddle-wheel, and the cranks retaining their parallelism throughout the revolution of the wheels, the paddles attached to spindles of the cranks of course do the same and are kept constantly vertical.

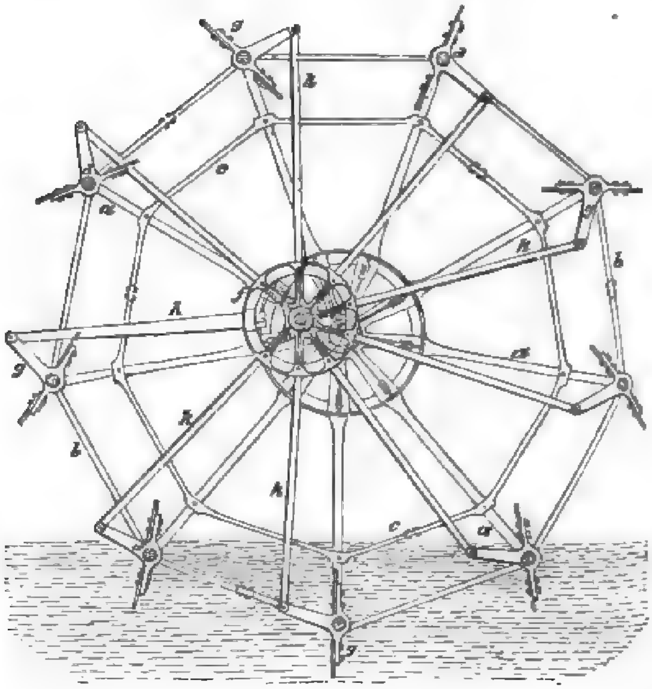
Oldham's Vibrating Float-wheel, (1827.)—This wheel in its general appearance and construction, greatly resembles Buchanan's invention already described, but by an extremely ingenious arrangement, the paddles, instead of being constantly vertical and parallel to each other (as in Buchanan's wheel), are constantly varying the angles which they form with each other, and are in every part of the revolution directed to the highest point of the wheel, or of the circle in which their axes are situated. By this peculiar position of the paddles the wheel is capable of working at any depth of immersion. The annexed figure is a side elevation of Mr. Oldham's wheel.



a a is the paddle-wheel, *b b* the floats or paddles, fastened to horizontal axles which are supported in bearings in the arms of the paddle-wheel, and which project beyond the arms on that side of the wheel which is nearest the vessel's side; *c c* a guide wheel revolving upon an eccentric disc *d*, placed upon the main shaft, between the paddle-wheel and the vessel's side. The guide wheel *c c* is connected to the paddle-wheel by means of short cranks, *e*, keyed on to the projecting ends of the axles of the floats, and having holes in their other extremity, in which work pins set in the face of the guide wheel. The length of these cranks must be exactly equal to the eccentricity of the disc *d*, and the distance of the pins in the face of the guide wheel, from the centre of the disc, must be equal to the distance of the float axles, and with these proportions the cranks will in all positions of the guide wheel remain parallel to each other. The eccentric disc is attached to a tube or long collar passing through the vessel's side, and the main shaft *f* of the paddle passes through the tube. The collar or tube revolves in bearings fixed upon the vessel's side, and upon the inner end is fixed a wheel working into a wheel, upon an intermediate shaft, which shaft

carries a second wheel, working into a wheel on the main shaft. These four wheels are so proportioned, that two revolutions of the main shaft shall cause the eccentric disc to revolve once upon the main shaft; thus, whilst the guide wheel by its connexion to the paddle-wheel revolves upon the disc, the disc itself is also revolving upon the shaft. All the paddles are fixed upon their spindles at different angles with the connecting cranks, so as to stand in the position shown in the figure; and as the disc during half a revolution of the wheel performs a quarter of a revolution on the shaft, the cranks, which in the figure are all vertical, would in half a revolution of the paddle-wheel stand horizontal, and therefore the whole of the paddles would in that time describe a quarter of a revolution on their axes, and the paddle which stood in a horizontal position at the top of the wheel, would, when at the lowest point of the wheel, stand vertically.

Morgan's Vibrating Float-wheel.—This wheel, although commonly known as "Morgan's Wheel," is in reality the invention of Mr. Elijah Galloway, who obtained a patent for the same in 1829. This patent was subsequently purchased by Mr. Morgan, who has since introduced several material improvements upon the original design. The annexed figure represents the wheel in its improved form as constructed by Mr. Morgan.

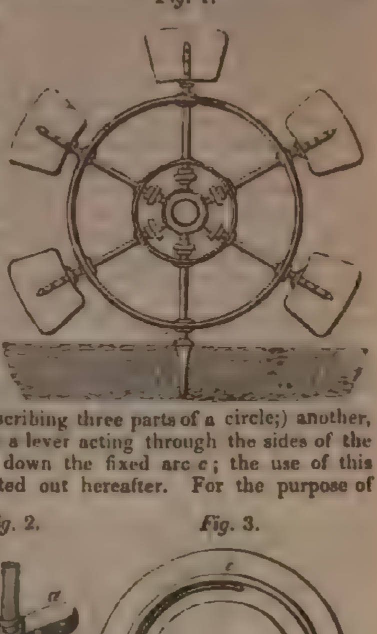


a a are the arms of the outer frame of the wheel, which are braced together by the two polygons *b* and *c*, and are connected to the arms of the inner frame of the wheel by strong tranverse horizontal stays *d d*. The paddle shaft does not extend beyond the boss of the inner frame, which is firmly keyed to it; the outer frame revolves upon an arm *e*, passing through its centre, and keyed into a carriage supported by the spring beam. This arm is formed into a crank between the outer and inner frames, and the pin of the crank supports the revolving collar *f*. *g g g* are brackets or stems which turn upon the stays *d d*,

arry the floats or paddles. One of these stems is connected to a stiff rod m *h*, which is keyed into the collar *f*; the other stems are connected to ollar by the radius rods *k k*, which turn upon pins in the collar and in the of the stem. The revolution of the wheel causes the collar to revolve by ction of the arm *h*, and the radius rods cause each paddle to assume in ssion the positions shown in the figure.

wson's Radiating Feathering Paddle-wheels.—The distinguishing feature of wheels is that the floats or paddles revolve or vibrate upon radiating or axes, so as to enter and leave ater edgeways, the planes lying lel to the keel or nearly so, but ing at right angles to it when fully rsed. The following description idged from Mr. Dawson's specifi- n, published in the Repository of

Fig. 1.



g. 1 represents a wheel the paddles hich gradually change their posi- as they enter and quit the water, h change is effected by affixing on axis of each paddle two wipers *a b* ing each other at right angles and e form shown in *Fig.* 2. To the of the vessel is fixed an immov- plate, on the surface of which are projecting arcs *c d e*, being por- of circles, as shown in *Fig.* 3. e of these arcs is immovable, (describing three parts of a circle;) another, aws in and out on guiding rods by a lever acting through the sides of the , the third arc *e* slides up and down the fixed arc *c*; the use of this g arc *e* will be particularly pointed out hereafter. For the purpose of

Fig. 4.

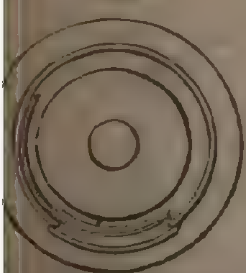
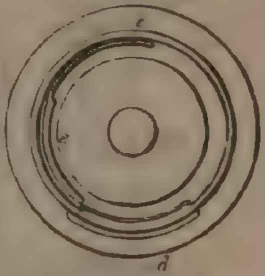


Fig. 2.

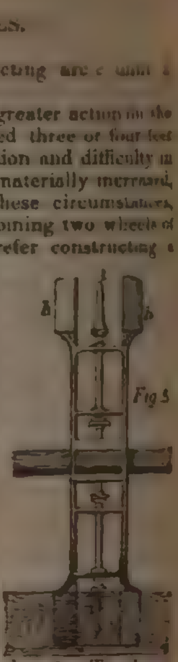
Fig. 3.



ing the change of position of each paddle gradually and without shock, the fixed and movable arcs terminate at each end in inclined planes. If are made long and the wipers in proportion, the motion will be very ally performed. When the wheel is made to revolve, the point of the *a* of the paddle entering the water encounters the commencement of the ed plane of the movable projecting arc *d*, rolls up it, and the paddle is by gradually turned one fourth of a circle on its axis; by which means osition of the paddle is changed from the edge on which it entered the to full surface, in which position it is retained by the movable arc *d*, and be made to act for any determinate space, say from *f* to *g*. The other *b* then encounters the inclined plane of the immovable arc *c*, rolls down the paddle is thereby gradually turned another quarter of a circle on its by which means it is turned round to the opposite edge on leaving the

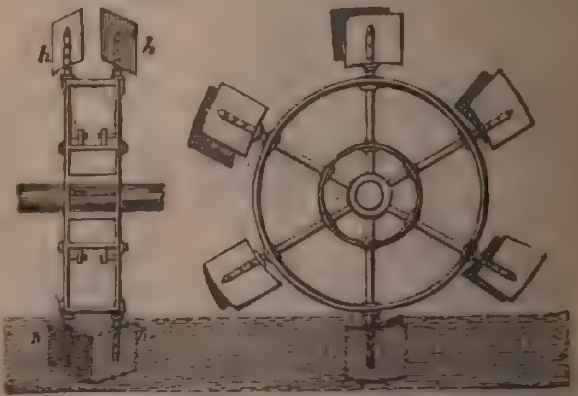
water. In this position it is retained by the fixed projecting arcs c until it again encounters the water.

Supposing it was required, with the view of obtaining a greater action on the wave, that the paddles of a feathering wheel should exceed three or four feet in breadth, say six or eight feet, it is obvious that the friction and difficulty in effecting the change of position in the paddles would be materially increased, and the number of paddles would be limited. Under these circumstances, instead of making a double feathering wheel, that is, of joining two wheels of three feet together to obtain the breadth required, I prefer constructing a feathering wheel with paddles three feet broad, on each side of which I fix shrouding boards *h h*, of twenty inches width, at a certain angle; by this means I avoid all increase of friction, check the lateral escape of the fluid from the paddles, and obtain a commensurate surface for the water to act on. Each paddle *i* and its fixed shrouding boards *h h* enter the water on their edges; as the wheel revolves, the paddle changes its position and presents its full surface, and thereby closes the open space between the boards, after a given time it gradually opens as it rises out of the water, and returns to its first position on the edges. By this arrangement, although the surface of action is increased, the ease of entering and escaping from the water is retained; and, according as the arcs are fixed on one side or the other of the wheel, the water will be thrown off the paddles in or out from the sides of the vessel.



It has been fairly objected to wheels on the above construction, that they are expensive, complicated, and work with much more friction than the wheels commonly employed. To obviate these objections I constructed the wheel shown in *Figs.* 6 and 7. The paddles of this wheel are formed of two boards posited at a certain angle face to face

Fig. 6. *Fig.* 7.

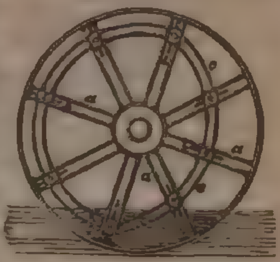


on their respective axes, leaving only a space sufficient for the free escape of the water between; in this position they are retained by stops from opening any farther. When the wheel revolves, the water acting on the broad surface of the paddles causes them to close as they enter the water, and to remain so until they begin to rise out of it, when the weight of the water lodging on the narrow surface only, causes them to open, and in consequence, the water falls through without being lifted.

Head's Patent Paddle-wheels, (Dec. 18, 1828.)—The principle of this invention is identical with one of those patented by Dawson in 1814, already

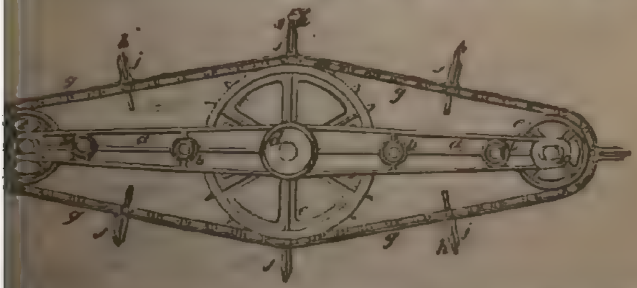
…. Each paddle consists of two leaves, fixed to radiating and revolving …, supported at the outer end by a cross bar attached to the opposite … the wheel, and at the other end by a similar …ched to the two bosses. That part of the …haft which lies within the bosses of the wheel …nded by a tube or collar, which passes through …he bosses, and is fastened to one side of the …ox, so that it remains stationary whilst the …volves. Upon this collar are fixed two bosses, …riphery of each of which is cut a groove …d of portions of two parallel circles, connected …blique channels as shown in the diagram; in …s the grooved boss fixed upon the collar b, … paddle-shaft revolving within the collar.

…g's *Eccentric Sliding Floats*, (1835.)—The object of these improvements …inish the resistance of the back-water; with this view the arms $a\ a$ of the …hich are fixed radially), have grooves …g the greater portion of their length, …ese grooves the paddle boards $b\ b$ are …n eccentric groove c is fixed to the side …ssel, and a corresponding groove is also …he spring beam of the paddle-box, and …ach end of the paddles works in these …nd regulates the distance of the paddle … centre of the wheel. The eccentric …re so placed as to cause the entering …o stand at the extremities of the arms, …t with full effect; but after passing the …ular the paddles are drawn by the … the eccentric grooves nearer to the centre of the wheel, so as to lift … water as they rise out of the water.



… *Chain Paddles.*—With the view of obtaining a direct impulse in the …e vessel's motion, in lieu of the oblique motion imparted by the …paddle-wheel, trials have been made at various times of floats attached … chains, passing over two drums placed at the sides of the vessel at a …ble distance asunder.

…'s *Endless Chain to Wheel.*—The accompanying engraving represents …ement of a propeller on this principle, for which Dr. Spurgin obtained …n 1837. It possesses some advantages over preceding arrangements …he principle, each paddle of the chain being made to enter and leave … at the angle required to produce the most effective action. For this



…stead of employing only two pair of riggers to carry the endless …ee pair are employed, the central pair being either of greater

diameter than the pairs at each end, or having its axis placed lower than the axes of the other two, so as to cause the lower sides of the chain to stand obliquely to the water, instead of parallel thereto, as in all previous propellers of this class; by this obliquity of the chain the paddles standing at right angles thereto are made to enter and leave the water at a corresponding angle.

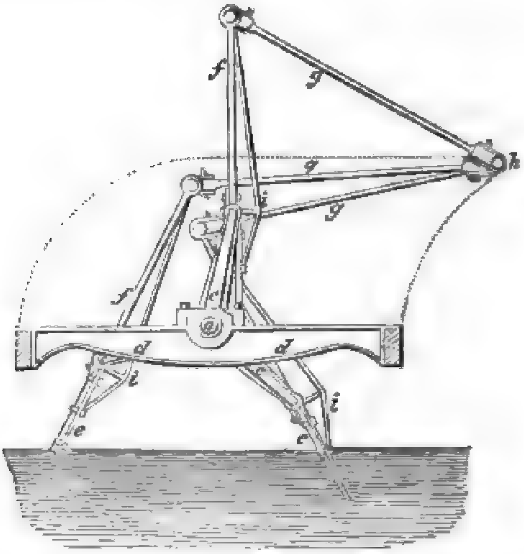
The figure represents a side elevation of the apparatus. *a a* is a cast iron frame secured to the sides of the vessel by the bolts *b b b b*, *c* is one of a pair of spike wheels fixed on the engine shaft *d*, *e e* riggers or pulleys running upon the pins or studs *f f* at each end of the frame, *g g* an endless flat chain passing round the riggers *e e*, and over and under the spike wheel *c*: in order to keep this chain tightly extended, the studs *f f* move in slots in the frame *a*, and are keyed up by any convenient method, so as to give the requisite tension to the chain; *h h* are the floats which are carried by the iron forks *j j*, which are forged in one with the middle links which support them.

Another improvement specified under the patent consists in the mode of constructing the chain. It is formed of single and double links alternately, the single links having on their backs a flange as broad as the double links, and projecting lengthwise half way over each double link, so that the flanges of the two contiguous single links abut against each other as shown in the figure, which represents a side elevation of a portion of the chain.

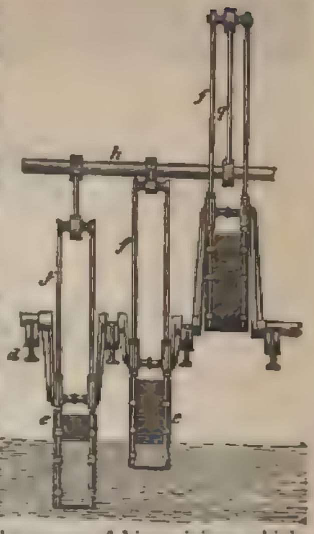
a a are the double links, *b b* the single links, and *c c* the flanges on the backs of the single links.

Stevens's Crank Axle Paddles, (1828.)—In this invention three paddles are attached separately to the arms of a three-throwed crank, and by means of radius and guiding rods connected with them, the paddles are each made to describe in the water the segment of an ellipse.

Fig. 1.



At *a*, *Fig.* 1, is the centre of the axis of a triple crank, the separate arms of which (marked *c c c*,) move between parallel bars on the side frame *d d* of the



paddle-box. At *e e e* are the three paddles, connected by the guide rods *f f f* to the radius rods *g g g*, the latter working from a fixed beam or centre *h*. At *i i i* are "arched spreaders" to keep the paddles firm and steady. *Fig.* 2, which represents a section through the horizontal beams *d d* shown in *Fig.* 1, is added, for the better explanation of the parts than could be done by words. This invention was much admired for its ingenuity when brought out.

Nairn's Propelling Apparatus, patented in 1828, is an example of what is termed the "Ducksfoot motion," consisting of two, four, or more levers suspended over the sides of a vessel, descending nearly as low as the vessel's keel. These levers are made to vibrate by the engine, and in order that they may experience but little resistance from the water in their back stroke, they should be of such a shape as to present in their horizontal section a form like the adjoining *Fig.* 1. At each side of the lever, at its lower extremity, is attached a broad plate of iron *a a*, *Fig.* 2, by means of hinge joints, which, upon the lever being moved forward, close and offer no resistance, but when it is moved backward, they open or expand, and thereby propel the vessel forward. They are prevented from opening beyond their proper angle by arcs or chains.

Fig. 1.

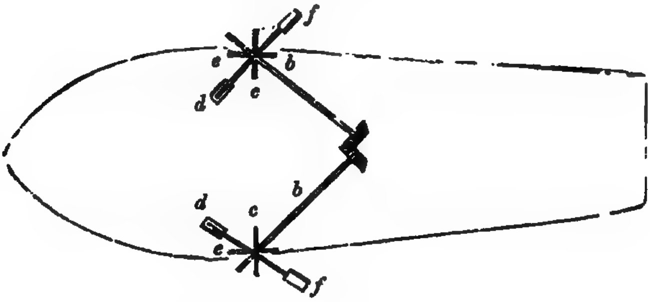
Fig. 2.

Perkins's Sculling Paddle-wheels.—In 1829 Mr. Perkins obtained a patent for the following mode of propelling, which may be considered as an example of sculling motion. Mr. Perkins places each of his paddles on the extremity of a radiating arm, in such a position that its plane if produced towards the centre of motion, would make with the axis of the paddle-wheel an angle of 45°. The axes of the paddle-wheels are not carried across the vessel, in the customary manner, but are carried in a direction sloping towards the stern, and they meet in a point in a straight line from stem to stern along the middle of the vessel, making with it an angle of 45° each, and with each other of 90°. On the extremity of the axis are fixed bevel wheels, which act upon each other, and are both acted upon by an intermediate wheel in connexion with the steam engine or first mover.

By this arrangement, the surface of each paddle, when immersed in the water at its greatest depth, is perpendicular to the side of the vessel, or to the line of motion, as represented at *c*, in the annexed figure in the marginal cut; at their greatest elevation, each paddle is parallel to the line of motion, as at *e*; and when in the horizontal position, whether ascending or descending, the paddles present an angle of about 45°; and, from the angle it deviates but little when in the act of entering or leaving the water, as the patentee proposes to immerse the wheel to about one-fourth of its diameter.

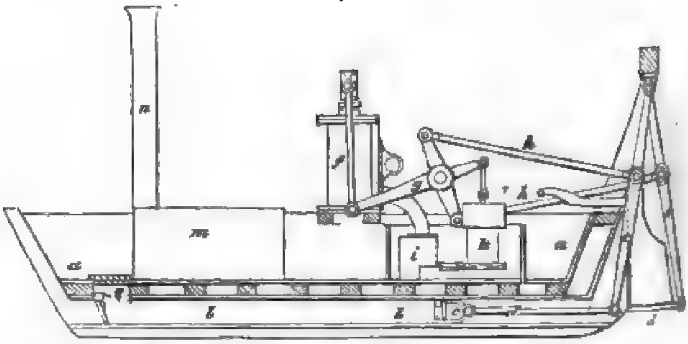
The annexed figure is intended to represent the outline, in plan, of a vessel with these paddles attached. At *a* is the boat, *b b*, the paddle axle, to which a uniform motion is given through the medium of the bevel gear which connects them; *c c* are two of the paddles immersed in the water, and in the act of

propelling; *d d*, *e e*, and *f f*, are those paddles which succeed each other in the revolution. The oblique action of the blades of the paddle, as they perform their revolutions, will be understood by reference to the cut before explained.



Linnaker's Propelling Pumps, (1808).—Mr. Linnaker proposed two plans for propelling vessels by means of pumps: in the first the pumps were placed horizontally beneath the vessel's bottom, and in the second, a pump was placed vertically within the vessel, and communicated with two horizontal channels formed below the vessel's bottom. The first plan is shown by *Fig.* 1, which represents a section of the boat, and the propelling machinery. *a a* is the vessel, which is flat bottomed, *b* one of two rectangular trunks which extend one on each side of the keel the whole length of the bottom. In each trough is a rectangular plunger *c*, fitting the trough, and connected by the rods *d d* to the hanging levers *e e*. These levers are worked to and fro by the steam engine *f*,

Fig. 1.



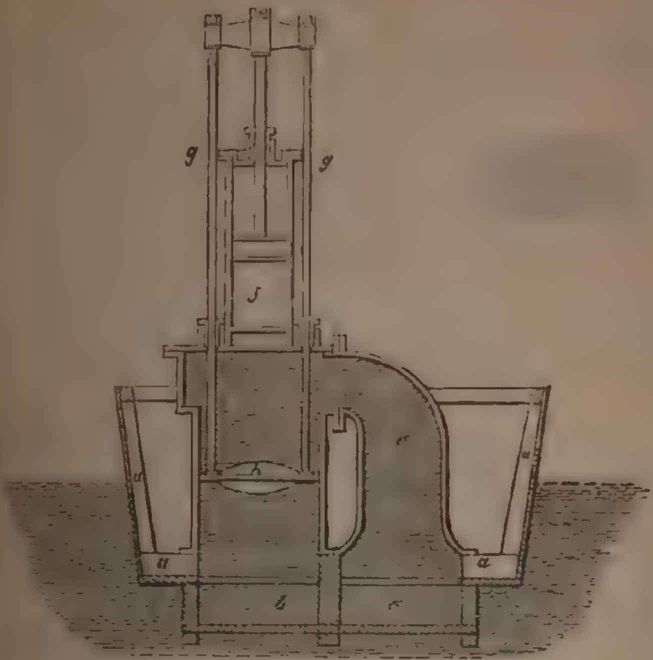
acting upon the bell-crank lever *g*, the cross arms of which are connected to the levers *e e* by the rods *h h*; *i* is the condenser, and *k* the air pump, *m* the boiler and *n* the funnel; *o* is a hanging valve, in the fore part of the trunk, and opening towards the stern. At each ascending and descending stroke of the engine, one of the plungers is thrust forward and the other backwards, and by the latter motion the water is drawn in at the valve *o*, and expelled at the hinder end of the trough.

Mr. Linnaker's second plan is similar in principle to the preceding, but its general arrangement is better, and more complete. It is shown in *Fig.* which represents a transverse section of the vessel and propelling apparatus.

a a a a is the frame of the vessel, which, as in the former instance, is f

tomed, *b* and *c* two rectangular troughs formed below the bottom, and tending the whole length of the floor, *d d* is a large vertical pump com-nicating below directly with the trough *b*, and connected at the upper part h the other trough *c*, by the elbow pipe *e*; upon this pump is fixed a vertical

Fig. 2.



am engine *f*, and to the cross head of the piston-rod are attached two side rods *g*, which pass through stuffing-boxes in the cover of the pump, and are ached to the piston *h* of the pump. The troughs are furnished at each end th a double set of hanging valves, so as to admit of reversing the motion of boat, which is effected by merely turning a lever, which throws one set of valves out of action, and puts the other set in operation.

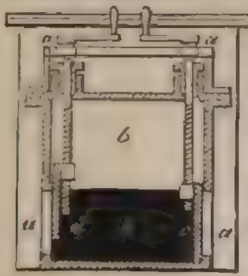
The action of this apparatus will be readily seen; at each stroke of the engine pump draws in water from the bows by the one trough, and expels at the rn water from the other trough, which by the reaction gives motion to the sel.

Busk's Hydraulic Propellers.—The principle of this plan of propelling sels has been termed the "reactionary principle;" it is thus explained by patentee.

It is well known that water contained in a vessel has a tendency to drive out sides, or burst such vessels by pressure in every direction in proportion to perpendicular height at which the water stands; and it is also well under-od that if an opening be made at any part of the vessel, the pressure on that t will be relieved by the flowing of water therefrom, at the same time the ssure in all other directions remains the same, so long as the head of water maintained at one water-line; and it will readily be understood, that if the sel were free to move, and had no opposing force greater than the unbalanced rnal pressure on the side of the vessel opposite, the opening would cause the

vessel to move in a direction opposite to the opening, such action resembling in principle the working of the hydraulic machine called Barker's Mill.

The mode in which this principle is to be applied to propel vessels may be thus described :—



a a in the figure represents a tank or cistern erected in any convenient part of the vessel, and supplied with water by a steam engine; *b b* is a section endways of a trunk branching from one side of the tank, and projecting over one side of the vessel at any convenient height above the water-line, a similar trunk projecting from the opposite side of the tank. Each trunk is furnished at its outer extremity with two sluice valves, the one of which (*c*) covers an aperture in the fore-side of the trunk, and the other (*d*) covers a similar aperture in the hinder or after side. Now if, both valves being shut, the tank be filled with water to any given height, the pressure upon the fore-side tending to propel the vessel forward will be as the pressure of the column of water; and supposing the pressure to be one pound per square inch, and that the sluice valves on each side are each twenty-five inches wide, then if the valves are raised one inch, the unbalanced pressure tending to urge the vessel forward will be fifty pounds. If it be desired to give the vessel stern way, the valves *d* must be closed, and the valves *c* opened.

Screw Propellers.—The idea of propelling vessels by a screw (in lieu of oars) is of ancient date; it is mentioned in the "*Machines et Inventions approuvées par l'Académie Royale des Sciences depuis* 1727 *jusqu'à* 1731." Franklin long afterwards suggested the same thing, but expressing doubts at the same time of its advantages to be obtained by the plan. In this country a patent was obtained in 1794 by a Mr. Lyttleton for "An Aquatic propeller," consisting of a screw of one, two, or more threads wrapped round a cylinder, and revolving in a frame placed at the head, stern, or side of a vessel. We believe this to be the first patent for a screw propeller.

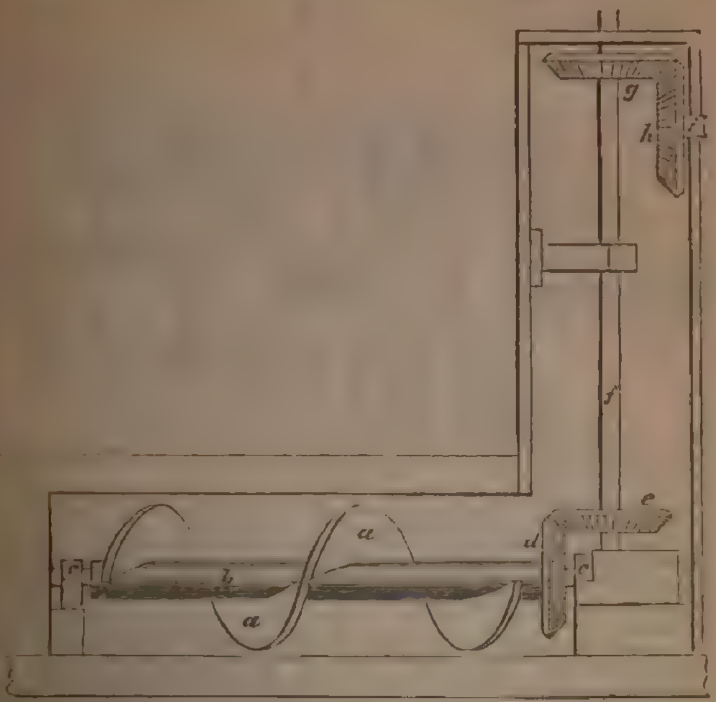
Various modifications of the screw have since formed the subject of seven patents, but it is only within a few years that screw propellers may be said to have come into operation.

Smith's Archimedean Screw Propeller, (1836.)—The annexed engraving represents partly in section the patented invention of Mr. F. P. Smith, to whose perseverance and energy is mainly owing the establishment of screw propelling.

a a is a screw or continuous spiral blade wound round a cylinder *b*, turning in bearings at *c c*; at *d* is a mitred wheel fixed to the shaft, and actuated by the mitred wheel *e* affixed to the vertical shaft *f*, at the upper end of which shaft is another mitre wheel *g*, which is driven by the wheel *h* fixed upon the engine shaft *i*; the screw works within an open space formed in the deadwood of the vessel, and the vertical shaft works in a well which is open both at top and bottom, so that the water rises to the level of the water line of the vessel. The shaft is steadied by one or more bearings *k* according to its length.

Mr. Smith constructed a vessel (which he named the *Archimedes*,) for the purpose of testing the merits of this mode of propelling, and the results were most satisfactory. In July, 1840, the vessel made an experimental voyage round this island, *viâ* Portsmouth, Bristol, Liverpool, Greenock, the Caledonian Canal, Inverness, Leith and Hull, and thence back to London. Up to her arrival at Hull she had steamed 1772 miles in 210 hours, being on an average about 8·2 miles per hour in all weathers and states of the tide. The government subsequently appointed a protracted trial to be made between the *Archimedes* and the *Widgeon*, a government steamer propelled by paddle-wheels, and from the success of the experiment were induced to order the *Rattler* steamer to be constructed with a screw propeller, and in this vessel experiments with

various modifications of screws have been made, which have firmly established the efficiency of the screw as a propeller, and it is now employed in numerous government vessels as well as private steamers.

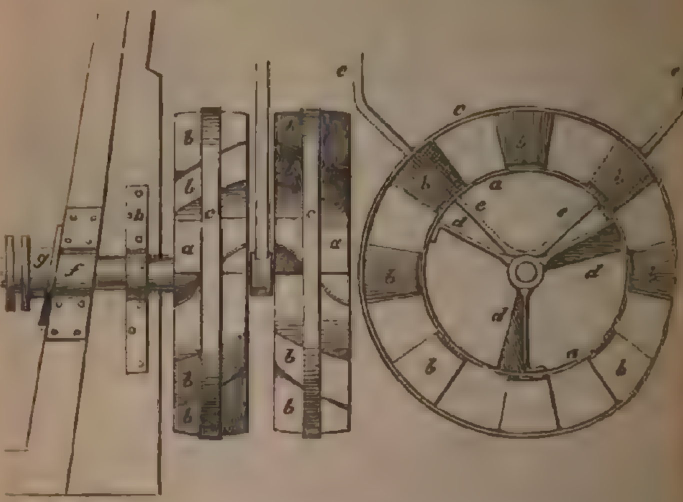


Ericsson's Screw Propeller.—In 1836 Captain Ericsson, a Swedish gentleman, well known for his mechanical talent, obtained a patent for an apparatus for propelling steam vessels. The invention consists in a modification of the water screw, or spiral propeller; but applied in a different manner to what has been usually proposed. *Fig.* 1 is an end view, and *fig.* 2 a side view of the apparatus.

Upon a broad cylindrical hoop *a* of wrought iron are placed light fans or vanes *b*, in an oblique, or rather a spiral direction, as the wheel may in fact be considered as a short portion of a screw of eight threads, the rake of which is about equal to the external circumference; or one turn of the screw would advance it through a space equal to the circumference. These fans are firmly twisted to the hoop *a*, and also to a narrow hoop *c* at their outer edges; and the hoop *c* is connected to its shaft by three broad wrought-iron arms *d*, set at such an angle as to offer the least possible resistance to the passage of the wheel through the water. Two of these wheels are suspended from the stern, by a strong framing *e*; the shaft of the outermost wheel passes through the shaft of the inner wheel (which is made hollow to receive it); and both shafts pass through an iron socket *f*, in the stern post, and through a stuffing box *g*, fixed to the stern post within the vessel, to prevent the entrance of the water. The set of vanes upon the two wheels stand in opposite directions; and the two shafts are connected to the engine in such a manner that the two revolve in contrary directions, and the outer wheel about one sixth faster than the inner one. As the shafts pass through the rudder, the upper and lower portions

are connected by a broad iron stay *h* on each side, of such form as to allow the necessary vibration of the rudder. The wheels are entirely immersed under the water.

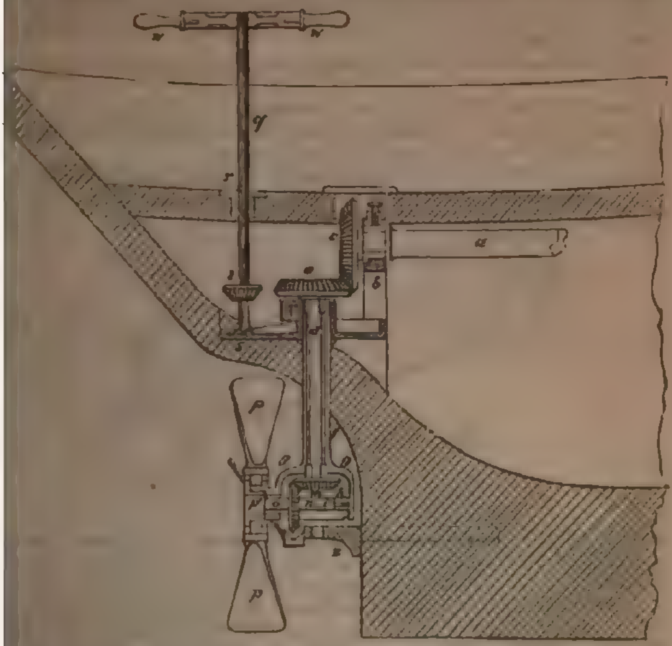
Fig. 2. *Fig. 1.*



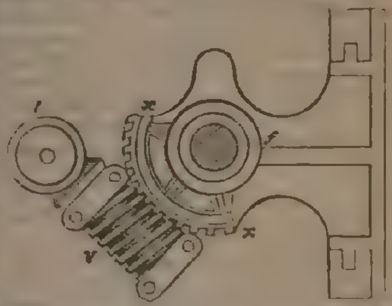
Hunt's Steering and Propelling Apparatus.—The distinguishing feature of this apparatus consists in its combining the two operations of propelling and steering in one. The following description we quote from the inventor's specification :—

"*a* is a driving shaft, connected in the usual way with a steam engine or other first mover; *b* an upright bearer on which the shaft *a* works; *c* a bevelled cog-wheel, attached to the end of the driving shaft, *d* a hollow vertical shaft (made hollow for the purpose of receiving occasionally a supply of oil to lubricate its different bearing points) which passes down, right through the stern of the vessel close to the water line, and reaches outside to near the keel, where it rests in a projecting heel-piece, *h*, bolted firmly to the keel or kelson, carrying at top a second cog-wheel *e*, which takes into the first cog-wheel *c*, and at bottom a third cog-wheel *m*, which takes into a fourth *n*, which acts immediately on the propellers hereinafter mentioned; *f* is a case which encloses the vertical shaft *d*, and is connected with it at top and bottom by gun-metal bearings; *g* a trunk (formed by an enlargement at the bottom of the case *f*,) which encloses and protects the third and fourth cog-wheels *m* and *n*, and is made of brass or some other metal not readily oxidizable; *i* is a short horizontal shaft on which the fourth cog-wheel *n* is fixed, one end of which shaft rests in the bearing *k*, inside of the trunk *g*, and the other passes through the trunk *g* into a coupling box *o*; *p p* is a nave or boss at the end of the coupling box, into which are fixed, at right angles the one to the other, the four blades or propellers *p*, by which progressive motion is given to the vessel. So much of the apparatus as I have hereinbefore described, is employed solely for propelling purposes, and its mode of operation is as follows:—The driving shaft on being set in motion by the steam engine or other first mover turns the first cog-wheel *c*, which turns the second cog-wheel *e*, which (through the medium of the shaft *d*,) turns the third cog-wheel *m*, which turns the fourth or last cog-wheel *n*, which turns the shaft *i*, which (through the medium of the coupling box *o*, and boss *p p*,) causes the blades or propellers *p*, to rotate and thereby propel the vessel. The steering part of the

I shall now proceed to describe. *w w* are the arms of a steering ...ed on the top of a vertical shaft *g*, which passes through the vessel's



...ning freely on its centre in the bearing *r*, and resting at bottom in a ... On this shaft a bevelled ...el *i* is fixed, the cogs of ...ork into a corresponding set ...at the end of a horizontal ...aft *v*, which takes into a ... *x*, (separately shown in ...ning cut, but omitted for ...clearness in the preceding ...which is attached to the top ...ase *f*, which encloses the ... shaft *e*. It follows from ... of combinations last de... that according as the ... turns the wheel to the ... or the other he must turn ...de or the other the quadrant *x*, which is attached to the top of the ...hich governs (through the medium of the shafts *d* and *i*, and the gear ... connexion with them) the position of the propellers, *p p*, and so cause ...pellers always to act in a line exactly coincident with that desired to be ... the vessel."



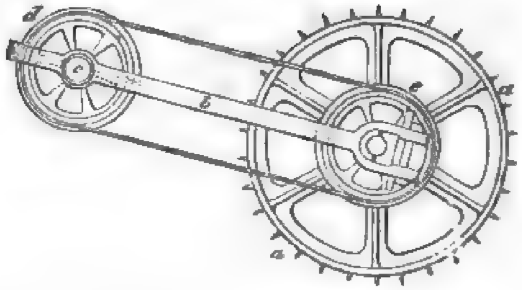
...*Navigation.*—The application of steam to the navigation of canals has ... considered a desideratum, and many plans have been brought for... the purpose, but none have been permanently adopted. Amongst the ... to its introduction, is the swell caused by the propelling apparatus, ...so destructive to the banks, that unless it could be obviated, it would ... counterbalance any advantages which might otherwise attend the use

of steam. Another obstacle is found in the narrowness of the locks, which leave little space for the fixing of the propellers at the side of the vessel. On the other hand, canals admit of the application of modes of propelling, by which a fixed fulcrum can be obtained in lieu of the yielding or receding fulcrum which is afforded by the water.

We shall notice a few of the inventions designed especially for this object.

Seaward's Spike Wheel.—Messrs. Seaward's plan for propelling vessels on canals and other shallow waters consists in the employment of a circular thrusting instrument or spike-wheel to act continuously.

In the annexed cut, *a* is the spike-wheel, working either outside the boat, or in a compartment within the vessel, but open at bottom. In order to

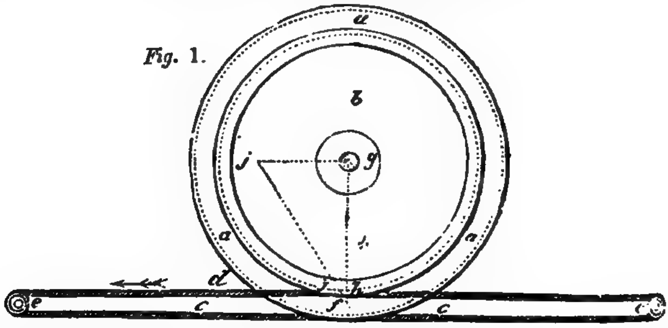


accommodate the wheel to the inequalities of the bed of the canal, it is supported by bearings at the extremity of a swinging frame *b*; the other end of which is hung to a shaft *c*, turned by a steam-engine; on this shaft is fixed a pulley or drum *d*, and a similar pulley or drum *e* is fixed on the axis of the wheel *a*, and an endless belt or chain being passed round the wheel, the revolution of the drum *d* causes the spike-wheel to revolve, and thereby propel the vessel.

Saxton's mode of Propulsion on Canals (1833).—This invention is intended for propelling light vessels at a high velocity on canals. It consists in a novel and ingenious application of the converse principle of the arrangement commonly known as the *Chinese* or differential crane, the latter being designed to move a great load through a small space, by a small force moving through a large space; whilst in this invention a small load is moved through a large space, by means of a great force moving through a small space.

In order that the invention may be fully understood, it will be necessary to

Fig. 1.

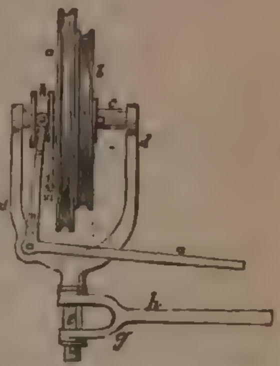


explain clearly the principle of it, before we describe the practical application. It is thus explained in the specification, which is given at length in the Repository of Arts.

represents a combination of two pulleys, their diameters being as six
a being the larger pulley, and b the smaller one; c d is an endless
ssing over the sheaves e e, which rope it should be observed takes a
nd each of the pulleys a and b, that is to say, the part c taking a turn
e larger pulley a, and the part d taking a turn round the smaller pulley b.
the rope d be caused to move in the direction of the arrow, it will
endency to draw the lower part of the pulley b in the same direction;
e part c of the endless rope will be moving in an opposite direction,
l have a tendency to move the lower part of the pulley a in the
rection; consequently, the two pulleys a b (they being fixed together)
turn on the mean point f, as a fulcrum; g is the centre of the two
Let it then be supposed, that the part d of the endless rope be
om h to i, it will be evident that the centre g of the differential pulleys
ld be moved to the point j; and consequently if any object were con-
o the centre g of these differential pulleys, it would be propelled from
e the endless rope being moved the much smaller distance of h to i,
ely indicated by the dotted lines; and these distances will be as thirteen

hall now describe the mechanical arrangement of the invention, as
to propel vessels on canals.

b are two pulleys upon one axis c,
ts of which turn in holes in the forked
the stem of which (e,) turns in sockets
he outer extremity of the arm h. The
is fixed to the axis, but the pulley b
upon the axis; k is a sliding clutch
e axis, carrying an arm m, in which is
ssing through a hole in one of the
the pulley a; n is a bent lever turning
pin in the forked frame d, and having
extremity, which embraces the sliding
When by the motion of the lever
ch is brought close to the pulley a, the
e arm m passes between the spokes
ulley b; and when it comes in con-
h one of them, it carries the pulley
ith the pulley a, and the machine is
gear. The opposite motion of the



thdraws the pin, and the pulleys are free to revolve in opposite direc-
nd the operation of the machine is suspended.

pparatus above described is supported over the side of the vessel by a
standard, which supports the arm h in a horizontal position; and the
opes are passed round the pulleys, as described, and through two
placed one at each end of the canal. If power be applied to draw the
any method, as for instance, by means of a steam engine applied to
of the riggers, the vessel to which the apparatus is attached will be
, with a velocity which will be to that of the rope, as it passes over the
n the ratio of the sum of the diameter of the pulleys, to their difference;
he diameters be as 8 to 9, the velocity will be as 17 to 1; and if the
turn with a speed of 2 miles per hour, the boat will be drawn at the
34 miles per hour.

ope must be supported upon rollers, placed along the banks of the
order that it may run light; and the object of making the stem of the
m in the sockets g g, is to allow the pulleys a and b to stand at an
which the endless rope may be led into the sheaves when the carriage
in a curved direction.

SECTION V.

ON THE PREVENTION OF ACCIDENTS FROM EXPLOSION, COLLISION, FIRE, FOUNDERING, &c.

Paramount necessity of precautionary regulations.—Government commission for inquiring thereon.—Extracts from Commissioners' Report thereon.—Abstract of Accidents on board of two Steam boats.—Regulations adopted by the Dublin Steam Packet Company.—Overhauling and examinations of Vessels and Machinery.—Reports.—Alarmingly unsafe condition of the Boilers of many Steam vessels.—Primary causes of Accidents.—Explosions.—Fires.—Collisions.—Outline of proposed legislative regulations for the prevention of.—"Rule of the road."—Steam —Captain Smith's Paddle-box boats.—Necessity of disengaging apparatus for Paddle wheels.—Murdoch's patent mode of effecting.—Act of Parliament for Regulation of Steam Navigation.

When it is considered that steam-vessels are principally employed in the conveyance of passengers, and that from the extent of their accommodations the number of persons assembled together is usually very great, frequently amounting to some hundreds, the paramount consideration should be to guard against accidents, where the consequences may involve the most appalling sacrifices of human life.

With the rapid extension of steam navigation it was to be expected that accidents would become more frequent; and, in 1831, a committee of the House of Commons was appointed to inquire into the subject, with a view to recommend preventive measures. The committee examined a number of witnesses, and presented two Reports; but these were not followed up by any legislative enactment; although some bye-laws were passed by the Corporation of London for regulating the speed of vessels in that part of the Port of London called the Pool. In the course of the year 1838, however, in consequence of some accidents of a serious nature, especially two explosions which occurred on board of one vessel within a short interval of time, and by which, we believe, in the whole, sixteen persons lost their lives, the attention of the Government was, in a more especial manner, called to the subject. They in consequence appointed Captain Pringle, R.E. and Joseph Parkes, C.E. to undertake an inquiry into the cause of such accidents, and the means of preventing the recurrence of them; in order to lay the ground of some legislative measure for the security of the public.

The chief points to which their attention was directed were—

1st. The number and nature of the accidents which have happened to steam vessels, within the last ten years, as far as can be ascertained.

2d. The practical means for preventing the recurrence of accidents.

In order to obtain this information they were directed to visit the principal ports, to confer with the local authorities there, the owners and officers of steam vessels, and the most eminent constructors of marine engines.

In compliance with these instructions the commissioners drew up a series of queries, which they circulated amongst parties connected with steam navigation; they visited the ports of Liverpool, Glasgow, Greenock, Leith, Newcastle, Shields, Sunderland, and Hull; and personally examined various steam vessels, some plying, and others undergoing repairs in their machinery and hulls, and received much valuable information from correspondents residing at places which their time did not permit them to visit. The substance of the information thus acquired is embodied in a well-digested report, in which most of the accidents are fairly traced to their true causes, and a number of valuable suggestions are

for the prevention of their recurrence. From this mass of authentic ...tion and of well-considered opinions we propose to make some extracts ...dation of the subject of the present section.

... the information obtained the commissioners were enabled to draw up a ...le of the accidents which have happened to life and property on board ...essels, within the period of the ten years preceding their report. This ...le, however, is to be considered as only an approximation to the real ... of accidents, and a few of them occurred anterior to that period, but ...entioned by one or more of their correspondents.

...following is a numerical abstract of the schedule.

ABSTRACT OF NINETY-TWO ACCIDENTS.

	Ascertained Number of Lives lost.
Wrecked, foundered, or in imminent peril	308
Explosions of boilers	77
Fires from various causes	2
Collisions	66
Computed number of persons lost on board the Erin, Frolic, and Superb	120
From Watermen's and Coroners' lists, in the Thames, exclusive of the above, during the last three years	40
From a list obtained in Scotland, exclusive of the above, being accidents in the Clyde, during the last ten years	21
	634

...greatest ascertained number of lives lost at any ...e time, occurred by the wreck of the Rothsay ...stle, when	110	persons perished.
...greatest number, at any one time, from collision	62	"
...greatest number, at any one time, from explosion	24	"
...greatest number, at any one time, from fire	2	"

...ollowing information and suggestion were derived from the evidence of ...C. Shaw, engineer and marine manager to the City of Dublin Steam ...Company, Liverpool: —

...ccidents have ever occurred in any of the Company's vessels from ...o, or rending of boilers. They construct and repair their own boilers, ...fer the cylindrical shape, with the internal flues of similar form. The ...re all separate, each containing its own water, and the steam-pipes have ... valves to shut off the communication with the other boilers. The ...ge of this plan is forcibly evinced in the case of the collision between ...ames and the *Shannon*. *The Thames must have gone down had the ... the different boilers not been distinct.*

...ngines and boilers of steamers are certainly not overhauled and repaired so ...ly as they should be. Experience has shown to the Company the value ...quent and minute system of overhauling and repairing. The arrival of ... of their vessels is instantly notified at the office, both at Liverpool and ... the foreman of the boiler makers, and the master engineer, immediately ...board, and are required within two hours to make a report in writing of ...al state of the engines, boilers, and all their apparatus, by filling up

printed forms prepared for each. The hull is inspected by a shipwright. Each vessel is placed on the gridiron at least once in every three months, merely to sight her bottom. The head fireman, having extra wages, is fined in the event of his not pointing out even if a rivet-head has sprung, or any other defect in his boiler during his last voyage.

The safety-valves in all their vessels are so arranged that the engineer can raise them to ease his boiler, but cannot load them beyond the assigned pressure; eight pounds per square inch is the highest pressure employed in their new cylindrical boilers. Vacuum valves, glass water-gauges, and a mercurial pressure gauge, fitted to all the boilers. The blowing-off and feed-cocks are of brass. In making new engines, they are also subject to a written detailed specification.

The Company's vessels are all constructed to a specification settled with Messrs. W. & J. Wilson, their builders; they are all much more substantial than the scantling required by Lloyd's Rules; they now build no vessels without iron water-tight bulk-heads. In the event of purchasing hulls built in other ports, they have them all in the graving-dock to be minutely examined, and such additional fastenings are added as are required to bring them up to their standard of strength.

The combustion of the coals has not unfrequently arisen in steamers from carelessness in dropping tow or waste among them, and leaving them there: and also from spontaneous ignition. The Company's boilers do not touch the skin of the vessel by many inches. The skin, or inside planking, is lined with sheet lead throughout the wake, or vicinity of the boilers; and the lead is covered over with thin sheet-iron. The addition of the lead is a most important feature, as it prevents charring. The boilers are all covered with dry hair-felt, and between them and the deck is a wrought-iron ceiling, resting on cast-iron beams. The coals are stowed in the space between the iron ceiling and the deck, with as much safety as in the iron coal-boxes. On the arrival of every vessel, a gang of coal-trimmers enter her and sweep down every atom of coal into the bunkers, for which we pay 5*s*. each trip, on the production of a certificate from the commander, that the work is done. By taking the duty off those on board, attention is secured to this important work; thus the old and often powdered coal gets burnt up first, and any defect in the ceiling-plates is at the same time discovered and remedied. A great saving of heat results from this complete covering, and the boiler tops are saved from the corrosion which used to take place when wet coals were stored upon them, or from rain or spray affecting them.

Boilers after being in use four years should be surveyed very frequently. After five years running, the boilers, timbers in their wake, deck-beams and ceilings, all require looking to, lest they might be injured; the middle of the vessel, which should be the strongest, becomes the weakest, after so long a period of working, in consequence of the skin being charred from constant heat. No steamer should have a license to ply which was not furnished with at least one valve inaccessible to the engineer or passengers, with a glass water-gauge to each boiler, and a mercurial pressure gauge, and always in order. The machinery should be inspected and certified by a competent, disinterested engineer, unconnected with any marine engine manufactory.

COPIES OF ORIGINAL REPORTS.

City of Dublin Steam Co's. Works, North Wall.

Mr. J. C. Shaw. *Dublin, 22 Jany. 1839.*

A Report of the state of the "Royal Adelaide" Boilers, this day, on her arrival from Belfast.

And find them in good order.

J. Marr. *James Powell, Foreman.*

City of Dublin Steam Co's. Works, North Wall.

Mr. J. C. Shaw. *Dublin, 22nd Jany. 1839.*

A Report of the state of the "Royal Adelaide" Engines, this day, on her arrival from Belfast.

And find them in working condition.

J. Marr. *A. Clegg, Foreman.*

City of Dublin Steam Co's. Works, North Wall.

Mr. J. C. Shaw. *Dublin, 24th Jany. 1839.*

A Report of the state of the "Duke of Cambridge" Engines, this day, on her arrival from London.

Two furnaces want repairing, and coal-bunkers will not do, which will take about two days.

J. Marr. *James Powell, Foreman.*

City of Dublin Steam Co's. Works, Clarence Dock.

Liverpool, 25th Jany. 1839.

A Report of the state of the "Queen Victoria" Hull, this day, on her arrival from Dublin.

In want of a new piece of rubber on the larboard side.

To Mr. J. C. Shaw. *Jas. M'Ardle, Foreman.*

The report states "that boilers are very frequently continued in use till they become dangerously thin; and that they are frequently deficient in safety apparatus is a fact, not only evidenced by the Table of Explosions, and instances given, but attested by a large majority of our correspondents. We were shown several in the yards of engine and boiler-makers, which (to use their own expression) 'might be walked through;' indeed, the hand might be pushed through some boilers which we examined, but recently taken out of steam boats. Mr. Shaw states, 'that the boilers of the *Fingal*, in 1835, were so weak that they had to be shored between the decks and the tops of them, which expanded and contracted like a pair of bellows.' Captain Bain writes that 'he has frequently had occasion, sometimes under very trying circumstances, to stop rents in boilers by temporary expedients; that he has witnessed it in other vessels, and has seen boilers worked till they were as thin as paper.'

"Some boilers, in actual use, are only kept tight by the deposit of mud, concretions of salt and sand, &c. between the flues; these obstructions to the passage of heat are not removed, as the metal of the boilers would give way, and they must then, necessarily, undergo repair, which is delayed till they will no longer hold together, or till ruptures occur, and have produced mischief.

"The explosion of deteriorated boilers is not the greatest danger to be apprehended from steamers so ill provided. Under the head of wrecks and founderings, the calamitous consequences of boilers failing at sea are still more fearfully exemplified.

"Great additional safety is obtained by employing several boilers, distinct from each other, rather than one only, or two boilers connected together; many dangers are avoided by this method. Independently of the obvious security arising from the means thus afforded of *shutting off* a disabled boiler,

and even of repairing it, whilst the motion of the engines is continued by the others, this arrangement possesses many other advantages, and cannot be too strongly recommended for general adoption.

"Several wrecks have been referred to by our correspondents, which might have been averted, had the paddle-wheels been furnished with *disengaging apparatus*, which is effected too slowly and clumsily by removing the floats,—an operation also difficult of accomplishment in tempestuous weather."

The primary causes of nearly all the accidents which occur to life and property on board steam-vessels, may be classed as follows:—

Of Wrecks, Foundering, or imminent peril of the same.

Causes.—Defectiveness of hull, boilers and engines, cables and anchors, crankness.

Of Explosions.

Causes.—Ignorance, carelessness, recklessness, and drunkenness of engine-men. Bad construction or insufficiency of safety-valves. Inattention to, or want of, proper apparatus to denote the level of water and pressure of steam in boilers. Malformation of boilers to sustain pressure. Working old boilers too long, and at too great pressure. Bad materials, and bad workmanship of boilers.

Of Fires.

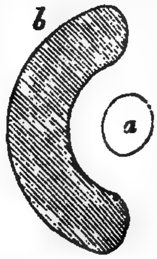
Causes.—Carelessness, and want of cleanliness. Bad construction of coal receptacles. Stowing coals on the boilers, and against the undefended sides of the vessel. Placing boilers too near the decks and sides of the vessel. Defective state of the boilers. Want of fire-extinguishing apparatus.

Of Collisions.

Causes.—Want of an universal code of night signals. Want of a defined and compulsory "rule of the road." Racing. Carelessness, or neglect of look-out.

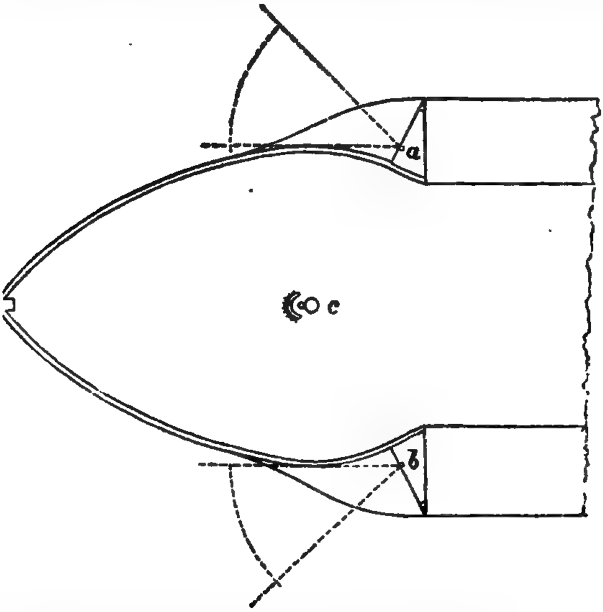
On this head the Commissioners observe:—"Collisions between steam-vessels, and between them and other craft, occur so frequently in crowded waters,—they are often so fatal to life, and so generally attended with litigation and expense in repairing damage, that the want of a law to diminish the evil is the subject of complaint by nearly all our correspondents. Collisions occur both by day and by night, at sea as well as in rivers. They commonly arise from the absence of a universal understanding as to 'the rule of the road' to be observed by vessels in meeting and passing each other, and from the absence of a universal system of *night-lights*, or signals."

Mr. Shaw introduced a system of night-signals in that Company's vessels in 1834, which has since been adopted by her Majesty's packets at Liverpool, and in other steamers. This system consists of one *white* light at the foremast head, one *white* light on the *starboard* paddle-box, and one *red* light on the *larboard* paddle-box. These are all resplendent and powerful lights. The mast-head light is transmitted through a large solid glass lens, so shaped and disposed that the light ceases to be visible abaft the beam. The marginal cut represents a horizontal section of this light; *a* being the light, and *b* the solid lens. The starboard paddle-box light is also transmitted through a solid glass lens; the larboard light through a hollow glass lens, containing a red mineral solution. These are placed in houses attached to the paddle boxes, and the rays are projected at an angle of about 35 degrees with the keel, so as not to dazzle the look-out men on the forecastle. They are visible at great distances. A diagram of the system is given in the cut on the next page, in which *a* is the starboard light (bright), *b* the larboard light (coloured), and *c* the mast-head light.



To secure the adoption of what may from time to time be proved as the most eligible methods of building and fastening a steam-

e first essential is, that a *written detailed specification* be prepared as of every contract, in which the dimensions, principle of construction, xtent, and size of the several fastenings be stated. The specification



lso be accompanied by working drawings of the mode in which such to be executed as cannot be given by mere description.

of proposed Legislative Regulations prepared by the Commissioners:—

at a Board be appointed in connexion with, and under the president Board of Trade, whose business it shall be to register and classify all navigated by steam, built or building: the register to record detailed tions of hull and machinery, periodical surveys to be made upon them, iculars of all disasters and accidents which happen to, or may be occay steam vessels.

he Board be authorized to appoint local or district surveyors to inspect rt upon the condition of steamers; that, on such report being satis- the Board shall grant licenses to the owners of steam vessels to t, if unsatisfactory, they shall withhold such license, as far as relates nveyance of passengers. Penalty for plying without license.

the Board be empowered to investigate personally, or otherwise, the nd causes of accidents, to examine witnesses on oath, and call for the on of papers.

the Board be required to make an annual report to parliament of its ngs, of the state and progress of the mercantile steam marine, and of sters which may have been sustained. That the records be public on nent of a reasonable fee.

the Board be empowered to frame and issue general instructions for dance of the local or district surveyors; also to publish an abstract of and regulations, with authority to require such abstract to be placed in cuous part of the vessel; under penalties on neglect.

2. That the surveyors of hull and machinery be paid for their surveys by the owners of the vessels according to a fixed scale, as is the practice for Lloyd's Register: that they shall forward their reports to the Board which, in the event of the owner or owners objecting to the repairs required in order to entitle the vessel to a passenger license, shall (if the objection regard the hull) call in one or two of the principal ship-builders of the port or district, unconnected with the work of such repairs, to survey the vessel in conjunction with the official surveyors, and report especially thereon.

Should the decision of the Board be objected to, on the report of the surveyor (if the objection regard the machinery), it shall call in the aid of one or more engineers to report in conjunction with such official surveyor.

Special surveys to be paid for by the owner, or owners, of the vessel, according to a fixed scale.

The first survey of the hull of a new vessel to be made during its construction, and a specification of it transmitted to the Board, as is now done by the surveyors of Lloyd's to the committee.

A survey of the hull to be made during each of the two first years, and a survey every six months subsequently. All steamers to be docked, benched, or laid on the gridiron (as circumstances permit), and surveyed, after sustaining any injury by taking the ground, or otherwise, under penalty.

The first survey of the boilers, engines, and machinery, to be made whilst they are being fixed in the vessel, and the requisite details of them to be reported to the Board.

Boilers, engines, and machinery, to be surveyed every six months after the first year, and all serious accidents to be reported.

The surveyors to report on the fitness of a vessel, whether as a sea-going or river-steamer.

3. License to express whether it be granted for cargo only, for towing vessels, for the conveyance of passengers, or for these purposes combined: also, whether the vessel be intended to ply as a river or sea-going steamer.

License to ply with passengers to be granted or withheld as aforesaid; a duplicate of which, or certificate to the same effect, signed by the Board, to be exhibited in the cabin, or other conspicuous part of the vessel. All public advertisements of steamers to state whether licensed to carry passengers or not.

An annual charge for each license to be made on all steam-vessels, varying according to a scale of size and capacity; such charge to be in no case less than £1, nor exceeding £5.

4. That the surveyor shall ascertain that the safety-valves be sufficient to pass all the steam which the boilers can generate in their ordinary state of work, at the pressure determined by the weight on the valves; the maximum of which pressure shall be fixed by the maker of the engines or boilers, and the valves be loaded accordingly.

5. That, after an assigned period, no passenger license be granted to any vessel having safety-valves whose spindles, or levers, are exposed on deck, or capable of being loaded externally, unless satisfactorily protected. Penalty on engineers, masters, or others, for loading valves beyond the weight ascertained by the surveyor, and regulated as above.

6. That in all new steamers, and after an assigned period in all steamers now afloat, glass water-guages, and mercurial pressure gauges, shall be required to be fitted to the boilers, to entitle the vessels to a license to ply with passengers.

No perfect mechanical substitute can be found for *care* in the management of the steam-engine at sea or on land; nor do we think that the use of the fusible discs, enforced by the French laws, would be productive of additional security; nor, indeed, that any complexity of apparatus attached to boilers would contribute to the attainment of that object.

Apparatus, however, for indicating the level of water and pressure of steam in boilers, is essential to their safe and economical management, and is of far greater import to the boilers of marine than of land engines; accidents to the former, or failure in their supply of steam, being attended with peculiar

gers and disasters at sea, from which land boilers are exempt. Yet it is a , accounted for, perhaps, by the circumstance of steam-vessels being owned managed, generally, by persons unacquainted with the nature of the n engine, that these simple instruments are much more rarely to be found ched to marine than to land boilers, which latter are usually under the ction of parties of mechanical education or knowledge.

That, in the event of the surveyor having information that any boiler eteriorated in strength, or unsafe at its working pressure, in the interval his periodical surveys, he shall be empowered by the Board, on his repreation, to examine it; and in the event of the boiler proving faulty, the rd shall suspend the passenger license, until satisfied of the safety of such ler.

That no steam vessel be permitted to ply which is not furnished a binnacle and compass in good order.

That, after an assigned period, no sea-going steam vessel, which es coals on the tops or about the sides of the boilers, shall be entitled to ssenger license; unless the boilers be protected by a shell of metal, or r sufficient security.

10. All river steamers to carry one effective boat, coasting and channel mers two or three boats, according to their size, and ocean steam-ships boats, as a minimum.

he surveyors to ascertain that these boats be kept in serviceable condition, ready for use on emergency.

11. All steamers to be provided with sufficient hoses, to convey water to part of the vessel, with a serviceable outfit of water-buckets; and a eable fire-engine to be carried in all coasting, channel, and ocean-going mers.

The proposed system of registration should include a classification of mers; and as the character to which each vessel would be entitled in its class ald depend on its general state of efficiency, we are disposed to think that ny other important requisites for attaining the utmost practicable degree of arity, would gradually be adopted by owners without compulsion; such as ter-tight bulk-heads in new vessels; powerful extinguishing pumps, worked the engines, connexion of the condensers with the bilge-water; disenging apparatus for the paddle-wheels; heavier and more effective ground khing, &c. The publication of accidents, and of their causes, would also n steam vessel owners, commanders, and engineers, and instruct them how guard against disasters.

In framing these recommendations, our object has been to suggest practical ans for further securing public safety, without inflicting vexatious rules on am vessel owners; we believe that their adoption would tend materially to omote, and in no respect to cripple, the progress of navigation by steam. e are confirmed in these views by finding them so much in accordance with majority of opinions expressed in the appendix: and they correspond with veral of the regulations enacted by foreign states. They are, however, much stringent in their nature than those proposed by many of our correondents; and we consider them much less onerous, and more suitable to the aracter of the British steam-marine, than the laws of other countries.

In order to diminish the frequency and danger of collisions, and being conced of the necessity for establishing a definite "rule of the road," and a uniform stem of signals, for the government of steam vessels, we should have introced into the foregoing outline distinct provisions on the subject, had it not en that a measure of this kind has been advised in the report of the "Comssioners appointed to inquire into the laws and regulations relating to the otage of the United Kingdom," (p. 161,) to be incorporated in a new Pilot t. Referring, however, to the tenor of our instructions as to "the nature the accidents in steam vessels," and to "the means of preventing them," d on a review of the valuable information supplied to us on this head, we nnot avoid recommending the adoption of a system which has for so many rs been found practically efficient—against which no objections have

hitherto been urged—and which has met the concurrence of so numerous a body of steam-navigators. The system we advise is—

1. As to the "rule of the road," that steam-vessels approaching and passing each other, should *starboard* their helms, with the view of keeping on the starboard side of each other respectively as far as practicable.

2. As to night signals,—the want of an uniform and sufficient system of lights has been so fruitful a source of collision and injury, we recommend a system similar to that now practised by a numerous class of commanders of private steamers (described p. 48), and which has been substantively approved of and adopted by the commanders of her Majesty's steam-packets at Liverpool: viz., that in all sea-going steam vessels, there be "a *white* light at the foremast head, visible in clear weather from eight to ten miles; a *white* light attached to the fore part of the *starboard* paddle-box, which can be seen six miles in clear weather; and a third light, which is *red*, attached to the fore part of the *larboard* paddle-box, visible about three miles. The three lights can only be seen at one and the same time when right a-head, or nearly so: in any other position, before the beam, two only are visible, and their colours define the position of the vessel."

3. That the obligation to carry some powerful steam-whistle, bell, or gong, be part of the proposed law as regards steam vessels; also, that their rate through the water be defined, during fog and thick weather, in crowded waters, whether plying by day or night.

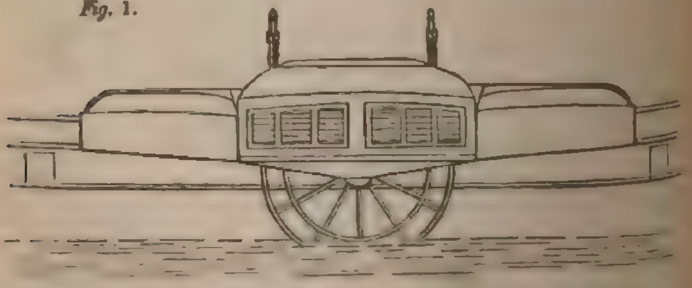
It is also obvious that some regulations are essential to determine the nature and enforce the carrying of lights in river-steamers, sailing-vessels, and vessels at anchor.

Owing to the number of passengers frequently embarked on board of steam vessels, it becomes difficult to provide the means of safety for all in the event of an accident which may render it necessary to abandon the vessel. A plan has recently been proposed by Captain George Smith, R.N., which goes far to meet this difficulty, and is calculated to be of essential service on such trying occasions. We extract the following account of this invention from Captain Smith's letter to Messrs. Pringle and Parkes.

"It is universally admitted, that steam vessels are very deficient in boats; so much so, that, when a steam vessel is lost, if the lives of the passengers and crew be not sacrificed, it may be considered an especial interposition of Providence.

"This deficiency, and the difficulty in steam vessels of carrying boats on deck, and in getting them in or out, have led me to turn my attention to the subject; the result has been the invention described in the accompanying drawing, which invention my Lords Commissioners of the Admiralty have been pleased to try on board her Majesty's steam vessel *Carron*, (a vessel of

Fig. 1.



between 200 and 300 tons burden.) The upper section of her paddle-wheel is covered by a life-boat (see *Fig.* 1.) twenty-five feet long and nine feet beam, having four air-tight cases, which may be removed if required on particular occasions. This life-boat is capable of containing between forty and fifty

...ons. When in her place over the paddle-wheel, the midship thwarts are ...pped, which admits of the wheel revolving within about six inches of her ...m.

The boat lies bottom upwards on two iron davits, having hinges, which enable ... be turned over and lowered down by six men in two or three minutes. ...s of similar capacity could not be got out, if stowed in the usual position

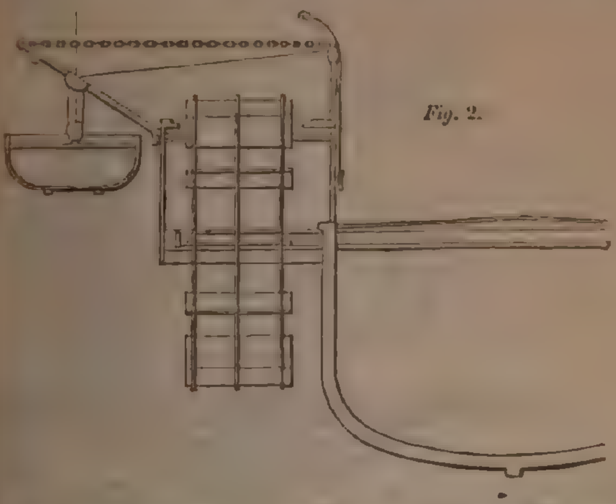


Fig. 2.

...ck, under twenty minutes by the whole crew, and in case of fire, probably ... all."

... 2 is a transverse section of the vessel, showing the boat on one side as ... over, and ready to be lowered down.

... is proposed, that steam-vessels should have one large boat over each ...-wheel; in the most powerful vessels they may be thirty feet in length, ... above nine feet beam.

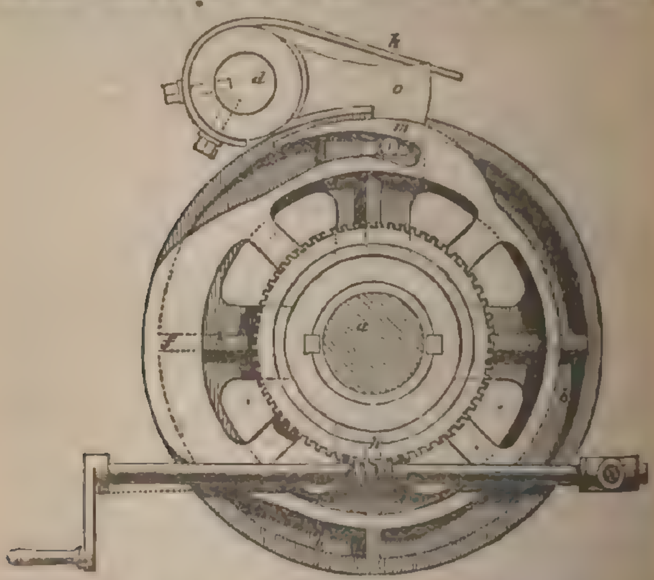
... Vessels fitted with boats on this plan present less resistance to the wind ...mosphere in sailing and steaming, and their appearance is considerably ...ved. The upper float-boards can be got at with ease when requisite, by ... the boat a little on her davits. If thought requisite to add to the ...r of boats, the cabins before and abaft the paddle-wheels may be roofed ... smaller boats." (As shown in *Fig.* 1.)

..., on many accounts, extremely desirable that steamers should be fur...d with the means of instantaneously disconnecting the paddle-wheels from ...gines, so as to leave each free to revolve independently of the other; ...any instances might be cited, wherein vessels have been lost for want of ...provision. Thus, in the melancholy case of the *Forfarshire*, the vessel, in ... gale of wind, with her engines broken down, was suddenly discovered ... within a short distance of rocks; sail was instantly set, and an attempt ...ade to wear her, but, owing to the resistance of the paddle-wheels, which ... still connected to the engines, she could not be forced through the water ..., but drove on shore, and was totally wrecked, with a loss of nearly ... lives. Again, the *Don Juan*, in fine weather, struck on a rock, and ... a serious leak, but which might have been got under by the pumps ... the engines, but the inner wheel being fixed on the rock, the engines ... not work, and the vessel was lost.

...ny plans have recently been brought forward for supplying the deside...m. The following cut represents one, for which Mr. Murdoch obtained a ...t in 1839. It will be seen that it admits of great solidity of construction,

can be readily adapted to engines of every form, and that its action is instantaneous.

To the paddle shaft *a* is attached, in lieu of the ordinary crank, a cylindrical drum *b*, having a gap or notch in its circumference into which a pall or drag



link *c*, suspended from the end of the crank pin *d*, falls, and this forms a connexion between the crank and the drum, so that the paddle shaft *a* and the engine shaft *e* revolve together. When it is required to disconnect them, the cam *f*, which is loose upon the boss of the drum, is turned by means of the worm *g* and worm-wheel *h*, and, pressing against the under side of the stud *i*, which projects from the side of the drag-link, it gradually releases the latter from the notch in the drum, and a portion of the cam being concentric with the drum, and of the same diameter, covers the aperture and prevents the link from falling into it during the revolutions of either shaft. *k* is a spring to counteract the centrifugal force of the link, and cause it to fall into the notch when desired in any position of the drum; and *m* is a horn projecting from the cam, which presses upon the stud *i*, and retains the link firmly in the notch.

Since the foregoing part of this treatise has been in the press, the recommendations contained in the report of the commissioners have been partially adopted; an Act of Parliament having been passed for the regulation of steam vessels, of which the following are the principal provisions:—

1. All steam-vessels built of iron of 100 tons burthen or upwards, the building of which shall have been commenced after the passing of the Act, are to be divided by transverse water-tight partitions, so that the fore part of the vessel shall be separated from the engine-room by one of such partitions, and so that the after part of such vessel shall be separated from the engine-room by another of such partitions.

2. From and after the first day of January, 1817, no vessel, the tonnage of which shall be 100 tons or upwards, shall proceed to sea, from any port whatsoever, unless it shall be provided with boats, duly supplied with all requisites for their use, and not being fewer in number, nor less in their dimensions, than the number and dimensions set opposite to the limits of dimensions in the following table, provided that the said limit of dimensions be not considered applicable to vessels engaged in the whale fishery :—

ing more than [illegible] passengers shall proceed to sea [illegible] dition [illegible] the boats [illegible] hereinbefore required, it shall [illegible] fitted [illegible] life-boat, with all requisites for its use, [illegible]

[illegible] building of which shall be commenced after the passing [illegible] all proceed to sea with a passenger, shall, in addition [illegible] the foregoing [illegible], and in lieu of a boat fitted up [illegible] either with such boats as are usually called paddle-box [illegible] boats as may be directed in lieu thereof by the Com[illegible] ity.

[illegible] of 100 tons burden or upwards shall proceed to sea [illegible] d with a hose for the purpose of extinguishing fire, [illegible] ed with the engines of the vessel.

[illegible] vessel as aforesaid proceed to sea without being [illegible] as aforesaid, or, being an iron steam vessel, without [illegible] or if any steam or other vessel of 100 tons burden [illegible] without being so provided with boats as aforesaid, [illegible] lost or rendered useless in the course of the voyage, [illegible] negligence of the owner or master, or if, in case [illegible] accidentally lost or injured in the course of the [illegible] having charge of the vessel wilfully neglect [illegible] first convenient opportunity, then [illegible] appear to be in fault, he shall forfeit [illegible] where the master or other person [illegible] in fault he shall forfeit a sum not [illegible] to clear out any such steam v[illegible] ond the seas without being [illegible] steam vessel, without being [illegible] or other vessel of 100 tons [illegible] and the seas, unless the same [illegible] required.

[illegible] when meeting or passing any [illegible] on the port side of [illegible] any river or narrow channel [illegible] the fairway or midchannel [illegible] side of such vessel, the [illegible] other person having [illegible] observe the regulations [illegible] respect forfeit and pay [illegible] and the [illegible] declaration [illegible] and [illegible]

t [illegible] g [illegible] the the ack, on d e, ated [illegible]e or circle circu[illegible] ts de[illegible]phery ex are [illegible]ey are [illegible]is view [illegible]chine is [illegible]ortable, be hung [illegible]fficiently [illegible]ty of pur[illegible] to the ex[illegible]ional parts

[illegible] conducted.

[illegible]ON, &c.

[illegible]ts, as contra[illegible] [illegible]ewise applied [illegible]n the tints and [illegible] piece of coiled [illegible]r stamped on to [illegible]s process; and we [illegible] practise it, on ac[illegible] [illegible]ly performed. [illegible] or of the sea, and in the purpose of building

Second. A declaration of the sufficiency and good condition of the machinery of such steam vessel, under the hand of an engineer to be approved by the Lords of the said Committee; such declarations bearing date of some day in the said months of April or October respectively.

And the Lords of the said Committee shall register such declarations, and shall transmit to the owners of such steam vessels respectively certificates, under the hand of one of the secretaries or assistant-secretaries of the said Committee, of the registry of such declarations.

9. If any steam vessel proceed to sea with passengers, the owner whereof has not duly transmitted to the Lords of the said Committee such declarations and received from the Lords of the said Committee such certificates of the registry of such declarations as herein before is mentioned, the owner of such steam vessel shall forfeit a sum not exceeding 100*l*.

10. Whenever any steam vessel shall have sustained or caused any serious accident, occasioning loss of life or property, or received any material damage affecting her seaworthiness, either in her hull or her engine, by grinding or by collision with any other vessel, or by any other means, the master or other person having the charge of such vessel shall, as soon as conveniently may be, transmit through the post office, by letter addressed to the Lords of the Committee of Privy Council for Trade, and signed by such master or other person, a report of such accident or damage, and the probable occasion thereof, stating therein the name of the vessel, the port to which she belongs, and the place where she is, in order that the Lords of the said Committee may, if they think fit, investigate the matter; and should the owner or owners of any steam vessel from her non-appearance or otherwise have reason to apprehend that such steam vessel is wholly lost, he or they shall, as soon as conveniently may be, in like manner send notice thereof to the Lords of the said Committee; and every owner, master, or such other person as aforesaid, who shall neglect to send such notice as hereby is required within a reasonable time after any such accident shall have happened, shall for every such offence forfeit and pay a sum not exceeding 50*l*.

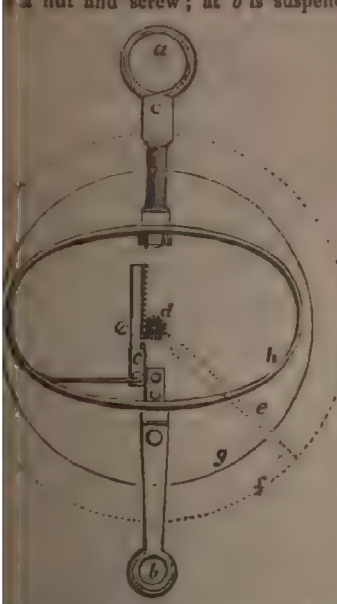
11. Whenever any steam vessel shall have sustained or caused any serious accident occasioning loss of life or property, or received any material damage affecting her seaworthiness either in her hull or her engine, by grounding or by collision with any other vessel, or by any other means, it shall be lawful for the Lords of the said Committee to appoint any proper person or persons as inspector or inspectors to inquire into and report upon such accident, and it shall be lawful for every person so authorized, at all reasonable times, upon producing his authority if required, to go on board and inspect any such steam vessel and the machinery thereof, and every part thereof respectively, not detaining or delaying the vessel from proceeding on her voyage, and to make such inquiries as to the nature, circumstances, and causes of such accident as he or they may think fit.

12. That nothing in this Act shall extend to any of Her Majesty's ships of war, nor to any vessel not being a British registered vessel.

STEEL. A peculiar combination of carbon with iron. It is chiefly used for edge tools, and other sharp cutting instruments, where great hardness is required; and from the fine polish of which it is susceptible, its applications to ornamental as well as useful purposes are as obvious as they are well known. See IRON.

STEELYARD. A machine for ascertaining the weights of bodies, usually denominated the Roman balance. It consists of a lever of unequal arms, suspended horizontally; to the shorter of the two arms is suspended the article to be weighed, and on the longer arm a weight is made to traverse, until the beam rests in a horizontal position; the position of the traversing weight indicates the weight of the article, which is engraved on the beam where the weight stops. See the articles BALANCE and LEVER. There is, however, another kind of steelyards in extensive use for domestic and other purposes, wherein great nicety in weighing is not appreciated. They are usually called "pocket steelyards," and

...s constructed:—In the centre of a distended spiral spring of many coils, ...tallic bar, on which are marked the divisions of the scale, according to ...ount of force or weight in pounds, requisite to compress the spring to ...int represented. To one end of the bar is rivetted a plate, to press upon ...ring, which are both in a cylindrical metal case; the other end of the bar ... freely through a hole in the bottom flat end of the case, where it is con... to a hook, on which the article or goods to be weighed are hung; and ...ing to their actual weight the bar, by compressing the spring, is externally ...ded, showing by the figure on the scale the weight of substance suspended. ...t variety of machines for indicating weight and pressure by the elastic ...nce of springs have been invented, and several have been described in the ... of this work, (see the articles DYNAMOMETER, CABLE, and others,) and ...ll here add one more, which has been brought into very extensive use by ...igence and skill of Mr. Marriott, of London. The machine we allude ...nominated Marriott's Patent Weighing Machine. It is an invention of ...ears standing, and the improvements made by Mr. Marriott relate to ...minutiæ, which, though of a subordinate, are not of a useless character. ...nexed diagram is illustrative of the construction of the internal part. ...e ring by which the machine is suspended: to the stem proceeding ...he ring the uppermost side of a strong elliptical steel spring is made ... a nut and screw; at *b* is suspended the scale, or other receptacle to hold the goods to be weighed; the stem of this is secured to the lowermost side of the spring, and likewise at its upper extremity to a vertical rack *c*, which is drawn downwards as the elasticity of the spring is operated upon by the weight; the descent of the rack turns a small toothed pinion *d*, on the axis of which is fixed a hand *e*, that points out upon the graduated circle *f*, the amount of the force or weight applied. The inner circle *g*, shows the periphery of the circular box, which encloses the parts delineated within it. The periphery of the front plate and the index are shown in dotted lines, as they are not supposed to be seen in this view of the apparatus. This machine is extremely convenient and portable, it requires no weight, may be hung up any where, and is sufficiently accurate for the generality of purposes, where inaccuracies to the extent of a few small fractional parts are of no moment.



...LL. The name of the principal vessel in which distillation is conducted. ...eat variety of them under the heads ALCOHOL, DISTILLATION, &c.

...PPLING. A mode of engraving on copper by means of dots, as contra...ished from a course of continued lines. The term is likewise applied ...mode adopted by some artists in drawing, of putting in the tints and ... of black lead or crayons, by means of the end of a piece of coiled ...harged with the pigment, with which it is stippled or stamped on to ...ace of the paper. Good artists generally despise this process; and we ...pinion that none but good artists should attempt to practise it, on ac... its wretched spiritless appearance, if not very ably performed.

...CKS. A frame erected on the shore of a river, or of the sea, and in ...e establishments in the inside of docks, for the purpose of building

ships. It generally consists of a number of solid wooden blocks, ranged parallel to each other at convenient distances upon a very firm foundation, and with a gradual declivity towards the water.

STRAND. One of the twists or divisions of which a rope is composed: also the name applied to any sea-beach, or shore, that slopes gradually down to the water's edge

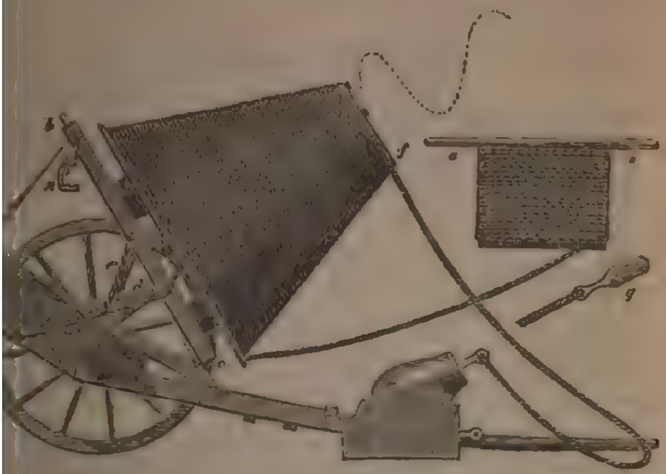
STRANDED, in *sea affairs*, a term, which, when applied to a rope, signifies that one, at least, of its strands is broken, but when applied to a ship, or vessel, it means that she has run on a rock or shoal, and been either rendered useless, or entirely dashed to pieces. The considerable loss every year of valuable lives, by shipwreck, on the British shores, had early attracted the notice of the Society of Arts, and premiums were offered for the discovery of effectual means of diminishing the frequency of these distressing calamities. In the year 1791, Mr. J. Bell, serjeant of artillery, proposed the projection of an eight-inch shell, loaded with lead, and having a light rope attached to it. The shell being discharged from a small mortar on the deck of a stranded ship would perform a range of about 200 yards, carrying the rope with it, and would bury itself in the sand on the shore, so as to form a communication with the land, by means of which boats, or rafts, might be hauled through the surf, and thus greatly facilitate the probability of escape from the wreck. The objections to this plan consisted in the difficulty of prevailing on the owners of merchant ships to incur the expense, and on the masters to have the apparatus in constant readiness for use. Besides which, many cases would no doubt occur, in which, from the pitching of the vessel, and from the sea beating over her, it would be impossible to project the shot in the right direction, or even to discharge the mortar at all.

In 1808, Capt. G. W. Manby, of Yarmouth, effected considerable improvements on the original proposal of Mr. Bell. These consisted in stationing the apparatus on the shore, instead of having it on board the ship, as, indeed, had previously been proposed by Mr. Bell; thus enabling, in the first place, a single apparatus to be used in aid of every vessel that might be driven ashore, on a considerable line of coast. Secondly, enabling the persons intrusted with the apparatus to become familiar with it, and therefore prompt in its application. Thirdly, increasing the probability of success by having the power of placing the mortar in the most favourable position, with regard to the vessel, and of arranging the rope, so as to render it much less liable to entangle, and thereby to break, than if it were thrown from the deck of the stranded vessel. The great personal activity and exertions of Capt. Manby in this very interesting and meritorious undertaking, were liberally seconded by the government, and the result, that on the eastern part of Norfolk alone, where Capt. Manby has been stationed, *no less than* 332 *persons have been rescued* from 48 stranded vessels between 1808 and 1826. Capt. Manby's original method of coiling or faking the rope on the shore, was an operation that required to be very dexterously performed; was impracticable in some places from the inequalities of the ground; was liable to derangement from the wind; occupied much precious time after the arrival of the apparatus, and scarcely admitted of being performed at night. A great improvement was subsequently made by Capt. Manby, in having the ropes arranged in baskets, which allows of their being now conveyed in a state ready for immediate use, to any place where they may be wanted. Under the management of Capt. Manby, and his immediate assistants, the breaking of a rope, in consequence of its getting foul while running out, is a very rare occurrence. Other persons less accustomed to the business, and, perhaps, less dexterous, have, however, frequently failed, and it seems to be generally allowed by the associations on the coasts of Norfolk and Suffolk, for relief in cases of shipwreck, that some more certain mode of faking or coiling the rope would be an important improvement.

In 1823, Mr. Hase, of Saxethorp, in Norfolk, being employed to cast a brass mortar for one of Capt. Manby's apparatus stationed near Cromer, constructed a skeleton reel, or rather conical spindle, as an improvement on Capt. Manby's baskets. This reel was supported by an axis, which allowed of its being placed

...uired angle; and the rope being wound round it, was expected to be ...ore freely, and with less risk of breaking, than by the usual mode. ...s made at Cromer confirmed the anticipations of the inventor, and ...us has now been in use for three years, and, apparently, has given ...action.

...Mr. Thorold has given to Mr. Hase's reel a stronger and more com... ...has both expedited and facilitated the coiling of the rope evenly upon ... placed the mortar and reel upon wheels, so that it may be trans... ...ditiously to any place where it is wanted. It is obvious, however, ...oing, the expense of the whole apparatus is greatly increased; that it ...ely capable of being conveyed by hand, as Capt. Manby's, and even ...is; and that, therefore, situations may occur, to which it would be ...not impossible, to bring it. The following figure presents a side ... the cart (with the near wheel off) and reel, and the mortar elevated



...tion for firing. The axis of the conical reel is fixed in the centre of ...ooden cross, which is framed and secured by four bolts to the bars ...are hinged at *c* to the cart; *d* is a bar of iron with holes, serving as ...; it is screwed on to the frame *b*, and one of the holes being placed ...ed in the cart's side, retains the reel at the required angle. Two ...e fixed on at each side of the cart, and to the frame *b b*, which ...while the reel is vertical, the elevator *d* catches the pin by its last ... *f* there is a *movable* ring and winch handle (not represented); *g* is ...turning on pivots in the frame *b*, on which is a sliding box *h*, to be ...ing the rope. Within the winch ring is a hook: a bend of the line ...d on this, the reel is turned once round, and the rope passed through ... the guide box *h*, properly constructed, and a pair of nippers (not ...When the mortar is to be fired, the guide bar *g* is thrown back into ... represented, and the winch. The pressure of the guide bar being ...off, the elasticity of the cord causes it to rise a little, and throw off ... of the upper coils; the next coil is kept in its place by one of the ...ying his finger on it, and not withdrawing it until the moment of ... mortar is to be placed a few yards to leeward of the reel, with the ...d to the shot. A clamp *n* hangs from the frame *b*, by means of ...ast coil of the rope is to be bound to the rim of the cone, in order

to secure it for travelling, the remainder of the line being on the frame o o. Another line, on a similar frame, is stowed in the tail of the cart; and in front of the axletree there is a locker for the shot, the peculiar form of which is shown by the separate figure *q*. The time required for winding the line, and firing the shot, is one minute and a half. Numerous certificates on the advantages of Mr. Thorold's apparatus, accompanied that gentleman's communication to the Society of Arts, who voted him the silver Vulcan medal:—a model of which invention is placed in the Society's Repository.

SUBERIC ACID. An acid obtained from cork; *suber* being the specific name of the cork-tree.

SUBLIMATION. An operation, by which volatile substances are collected and obtained. It is nearly allied to distillation, excepting that in the latter, the fluid parts only of bodies are raised, whereas, in sublimation, the solid and the dry are obtained. Flowers of sulphur are obtained in this way; and the soot in our chimneys is a familiar and perfect illustration of sublimation.

SUCCINIC ACID. An acid extracted from amber, by distillation.

SUCKER. A name given by plumbers to the bucket, piston, or rising valve of a pump: see PUMP.

SULPHATES. Definite compounds of sulphuric acid with the salifiable bases.

SULPHITES. Definite compounds of sulphurous acid with their bases.

SULPHUR. A simple inflammable body. Its fusing point is 220° Fahr. after which it begins to evaporate; at 560°, it takes fire in the open air, and burns with a pale blue flame: kept melted in an open vessel at 300°, it becomes of a red colour, thick, viscid, and plastic, like wax, and is used by seal engravers to take off impressions from their work. Its great utility in the arts is too well known to need specifying.

SULPHURETS. Combinations of the alkalic earths, and metals, with sulphur.

SULPHURIC ACID: see ACID, SULPHURIC.

SUMACH. A vegetable substance, extensively employed in tanning and dying. It consists of the young shoots of a shrub, that grows naturally in many parts of the Mediterranean; the shoots, after being dried, are reduced to powder in a mill, which adapts it to the immediate use of the tanner and dyer: it abounds in tannin and the gallic acid, strikes a deep and rich black with the salts of iron, and is eminently valuable in the arts alluded to, (which see,) and many others.

SWIVEL. A kind of ring or link of a chain, that is enabled to turn round by jointing it to the next, by means of a pin or axis. The term of swivel is applied to a small cannon, provided with a similar kind of joint; and to use numerous purposes, *swivel-joints* are adapted and modified in a variety of ways too unimportant to describe.

SWORD. A long-bladed knife, fashioned in various ways, but all designed for mangling or destroying the human species.

SYRINGE. A simple hydraulic machine, employed to draw in and discharge fluids violently. It consists merely of a small tube, in which is fitted a piston or plunger, and having a small hole at the bottom of the tube, through which the liquid enters, when the plunger is drawn back, and charges the tube. Then, by forcing the plunger forwards, the fluid is expelled with a violence proportioned to the velocity given to the plunger.

T.

TABBY. The name of a rich kind of silk, which has undergone the operation of *tabbying*; which consists in passing between metalic rollers the surfaces of which are variously engraven, producing thereby the device on the stuff, by laying down the fibres in one part, and leaving them erect in the other, rendering them conspicuous by the difference of light and shade

BLES. In *mathematics*, they are the results of calculations, systematically ged, for the convenience of ready application. They also serve the useful ses of testing the accuracy of a person's own calculations. Numerous are given in various parts of this work, attached to the subjects to which are related.

CAMAHAC. A resin, having the odour of musk, soluble in alcohol.

CKLE. A term sometimes applied to a pair of pulley-blocks and ropes, for raising or removing weights.

CKS. Small nails. See NAILS.

FFETY. A very rich, glossy, silk stuff, plain, flowered, gold-striped, &c.

LC. A soft unctuous mineral, occurring in beds, in mica-slate, and clay- It is found in several parts of Scotland, but the best comes from the bourhood of the Tyrol. It is employed as an ingredient in rouge for the s, along with carmine and benzoin. This cosmetic communicates a able degree of softness to the skin, and is not injurious. The flesh is given to gypsum figures, by rubbing them with talc.

LLOW. Animal fat melted down and clarified. See FAT.

MBOUR. A species of embroidery, in which threads of gold and silver y needles of a peculiar form, worked in leaves and flowers, &c., upon a uff, stretched over a circular frame, called a tambour.

NNIN. A peculiar vegetable principle, so named because it is the effective in *tanning*, or the conversion of skin into leather. See LEATHER.

PESTRY. A species of woven hangings of wool and silk, adorned with representations in imitation of painting, and employed formerly for the walls of elegant apartments, churches, &c. The French ascribe the ion to the Saracens; and hence the workmen employed in it were called ns. Guicciardini ascribes it to the Dutch. A manufactory was esta- at Paris, by Henry IV. in 1606 or 1607, which was conducted by h artists. It was brought to England by Wm. Sheldon, in the reign of VIII.; and in 1619 a manufacture was established at Mortlake, in , by Sir Francis Crane, who received 2000*l.* from King James to ge the design. The manufactory of the Gobelins in France became the celebrated for the beauty of the colouring, and the elegance of ; the first-rate painters being employed to furnish subjects.

PIOCA. A gummy kind of starch, prepared by the Brazilians from the the casava plant. A spurious tapioca has been manufactured in this y, from the farina of the potato; the process of preparing the latter ing simply in exposing the dry farina to the action of a moderate heat open pan, and continually stirring it up to prevent carbonization; the of crystallization of the starch, causing a species of fusion of the starch, conglomerates into little masses, of a semi-transparent gummy appearance, h an efflorescent surface, much like the foreign tapioca in appearance; hough it possesses similar properties as an aliment, it does not form so nor so agreeable a "jelly." A patent was recently taken out for the just described; but unfortunately for the patentee, it was well known, nearly half a century before the date of his patent. The advantage of cess is, however, to us more than doubtful, whilst the foreign article can ined, subjected to only a moderate import tax.

R. A thick black unctuous substance, obtained chiefly from old pine trees, by burning them with a close smothering heat. It is prepared in uantities in Norway, Sweden, Russia, Germany, North America, and in ountries where the pine and fir abound.

mode practised in the Scandinavian peninsula, is similar to that described ophrastus and Dioscorides, as in use in ancient Greece. A conical cavity in the earth, with a cast-iron pan at the bottom, to which is connected a carry off the liquid. Billets of wood are thrown into the cavity, and being vered with turf, are slowly burnt without flame. The tar which exudes the combustion, is conducted by the before-mentioned pipe into barrels, are afterwards bunged up, and are then ready for exportation

Becher, the celebrated chemist, first proposed to make tar from pit-coal. Manufactures for this purpose have been established many years ago, in several parts of England. In the year 1781, the earl of Dundonald obtained a patent for extracting tar from pit-coal, by a new process of distillation; a kind of tar is also produced from the pit-coal used in the production of gas for illumination. See GAS: also PITCH.

TARPAULIN. A piece of strong canvass, or sail-cloth, well saturated with tar, and dried; employed extensively for covering goods in ships, barges, waggons, carts, &c.; also for protecting stacks and ricks of agricultural produce from the effects of the weather, &c.

TARRAS, or TERRAS. A volcanic earth used as a cement. It differs but little from puzzolana, but contains more heterogeneous particles, as spar, quartz, shorl, &c. It effervesces with acids, is magnetic, and fusible *per se*. When pulverised, it serves as a cement, like puzzolana. It is obtained from Germany and Sweden.

TARTAR. A substance deposited on the sides of wine casks, during the time that the wine is in a state of fermentation. This substance being scraped off, and in its natural and unpurified state, is called by chemists super-tartrate of potash, and popularly, crude tartar. Tartar is distinguished, from its colour, into red and white, according to the colour of the wine from which it originates. All wines do not afford the same proportion of tartar; according to Dr. Newmann, the wines of Hungary yield but little tartar, those of France somewhat more, while the Rhenish wines afford the purest tartar in large quantities. The method adopted at Montpelier, according to Dr. Ure, for purifying this substance from an abundance of extractive principle, is as follows. "The tartar is dissolved in water, and suffered to crystallize by cooling; the crystals are then boiled in another vessel, with the addition of five or six pounds of the white argillaceous earth of Murviel to each quintal of the salt. After this boiling of the earth, a very white salt is obtained by evaporation, which is known by the name of cream of tartar, or the acidulous tartrate of potash," or purified super-tartrate of potash.

Emetic tartar is the tartrate of potash, and antimony. *Regenerated tartar*, the acetate of potash. *Salt of tartar*, the subcarbonate of potash. *Soluble tartar*, the neutral tartrate of potash. *Vitriolated tartar*, sulphate of potash.

TARTARIC ACID. An acid obtained from the above-mentioned salt tartar by Scheele. In a solution of the super-tartrate in boiling water, he saturated the superfluous acid by the addition of chalk, as long as effervescence ensued; and expelled the acid from the precipitated tartrate of lime, by means of the sulphuric. Or four parts of tartar may be boiled in 20 or 24 parts of water, and one part of sulphuric acid added gradually. By continuing the boiling, the sulphate of potash will fall down. When the liquor is reduced one-half, it is to be filtered; and if any more sulphate be deposited by continuing the boiling, the filtering must be repeated. When no more is thrown down, the liquor is to be evaporated to the consistence of a syrup; and thus crystals of tartaric acid, equal to half the weight of the tartar employed, will be obtained.—*Ure.*

TARTRATE. A neutral compound of the tartaric acid, with a base.

TAWING. The art of preparing white leather. See LEATHER.

TEA. The dried leaves of the tea-plant, which is a native of Japan, China, and Tonquin. The history of commerce does not perhaps present a parallel to the circumstances which have attended the introduction of tea into this country. The leaves were first imported into Europe by the Dutch East India Company, in the early part of the seventeenth century; but it was not until the year 1666 that a small quantity was brought over from Holland; and yet, from a period earlier than the memory of but few of the present generation can reach, tea has been regarded as one of the principal necessaries of life among all classes of the community. To provide a sufficient supply of this aliment, many thousands of tons of the finest mercantile navy in the world are employed in trading with a people by whom all dealings with foreigners are merely tolerated; and from this recently-acquired taste, an immense and easily-collected revenue is obtained by the state.

The tea-plant is an evergreen, somewhat resembling the myrtle in appearance, bears a fragrant yellow flower, and grows to a height varying between three and six feet. It is capable of enduring great variations of climate, being cultivated alike in the neighbourhood of Canton, where the heat is at times almost insupportable to the natives, and around the walls of Pekin, where the winter is, not unfrequently, as severe as in the north of Europe. The best sorts, however, are the production of a more temperate climate; the finest teas are said to be grown in the province of Nanking, occupying nearly the middle station between the two extremes mentioned above; and the greatest portion of what is brought to the Canton market, and sold to the European merchants, is the produce of the hilly, but populous and industrious, province of Fokien, situated on the sea-coast, to the north-east of Canton. It appears to thrive best in valleys, or on the sloping banks of hills, exposed to the southern sun, and especially on the banks of rivers or rivulets.

The tea-plant is propagated from seed, and the holes are drilled in the ground at equal distances, and in regular rows; into each hole the planter throws as many as six, or even a dozen seeds,—not above a fifth part of the seed planted being expected to grow. While coming to maturity, they are carefully watered; and though, when once out of the ground, they would continue to vegetate without further care, the more industrious cultivators annually manure the ground, and clear the crop from weeds.

The leaves of the tea-plant are not fit for gathering until the third year; at which period they are in their prime, and most plentiful. When about seven years old, the shrub has generally grown to about the height of a man, and its leaves become few and coarse; it is then generally cut down to the stem, which, in the succeeding summer, produces an exuberant crop of fresh shoots and leaves; this operation, however, is sometimes deferred till the plant is ten years old.

The process of gathering the tea is one of great nicety and importance. Each leaf is plucked separately from the stalk; the hands of the gatherer are kept carefully clean, and, in collecting some of the fine sorts, he hardly ventures to breathe on the plant. Notwithstanding the tediousness of such an operation, a labourer can frequently collect from four to ten, or even fifteen pounds a day. Three or four of these gatherings take place during the season; viz. towards the end of February, or the beginning of March; in April or May; towards the middle of June; and in August. From the first gathering, which consists of the very young and tender leaves only, the most valuable teas are manufactured; viz. the green tea called gunpowder, and the black tea called Pekoe. The produce of this first gathering is also denominated in China, Imperial tea, probably because, where the shrub is not cultivated with a view to supplying the demands of the Canton market, it is reserved, either in obedience to the law, or on account of its superior flavour, for the consumption of the emperor and his court. From the second and third crops are manufactured the green teas, called in our shops Hyson and Imperial; and the black teas denominated Souchong and Congou. The light and inferior leaves separated from the Hyson by winnowing, form a tea called Hyson-skin, much in demand by the Americans, who are also the largest general purchasers of green teas. On the other hand, some of the choicest and tenderest leaves of the second gathering are frequently mixed with those of the first. From the fourth crop is manufactured the coarsest species of black tea called Bohea; and this crop is mixed with an inferior tea, grown in a district called Woping, near Canton; together with such tea as remained unsold in the market, of the last season.

Owing to the minute division of land in China, there can be few, if any, large tea-growers; the plantations are small, and the business of them carried on by the owner and his own family, who carry the produce of each picking immediately to market, where it is disposed of to a class of persons whose business it is to collect and dry the leaves, ready for the Canton tea-merchants.

The process of drying, which should commence as soon as possible after the leaves have been gathered, differs according to the quality of the tea. Some are only exposed under a shed to the sun's rays, and frequently turned. A

drying-house will contain from five to ten or twenty small furnaces, on the top of each of which is a flat-bottomed and shallow iron pan; there is also a long low table, covered with mats, on which the leaves are spread and rolled, after they have gone through the first stage of the process, which we may call baking. When the pans are heated to the proper temperature, a few pounds of fresh-gathered leaves are placed upon them; the fresh and juicy leaves crack as they touch the pan, and it is the business of the operator to stir and shift them about as rapidly as possible, with his bare hands, until they become too hot to be touched without pain. At this moment, he takes off the leaves with a kind of shovel, like a fan, and pours them on the mats before the rollers, who, taking them up by small quantities at a time, roll them in the palms of their hands, in one direction only; while assistants with fans are employed to fan the leaves, in order that they may be the quicker cooled, and retain their curl the longer. To secure the complete evaporation of all moisture from the leaves, as well as the stability of their curl, the operation of drying and rolling is repeated two or three times, or even oftener, if necessary,—the pans being, on each successive occasion, less and less heated, and the whole process performed with increasing slowness and caution. The leaves are then separated into their several classes, and stored away for domestic use, or for sale. It was, at one time, supposed that the green teas were dried on copper pans, and that they owed their fine green colour to that circumstance, which was also said to render a free use of them noxious to the human frame; but this idea is now held to be without any foundation, the most accurate experiments having failed in detecting the slightest particle of copper in the infusion.

After the tea has been thus gathered by the cultivator, and cured and assorted by those who, for want of a better name, we may call tea-collectors, it is finally sold to the "tea-merchants" of Canton, who complete the manufacture by mixing and garbling the different qualities, in which women and children are chiefly employed; the tea then receives a last drying, is divided according to quality, packed in chests, and made up into parcels of from one hundred to six hundred chests each, which are stamped with the name of the district, grower, and manufacturer, and called from a Chinese word, meaning *seal* or *stamp*, Chops.

In perusing the foregoing process of drying the tea, our mechanical readers will probably think with us, that it might be much better (or more uniformly) performed by a machine, heated by steam at a regulated temperature, and that full nine-tenths of the labour would thereby be saved. But as such a proposition to the manufacturers of the "Celestial Empire" would probably be regarded with indignation, and be rewarded, if it were possible, with the bastinado, we shall reserve our suggestions for a fitter object. Those of our readers who may wish for more important information respecting the progress of this important trade, than our limits enable us to give, will find it in M'Culloch's *Dictionary of Commerce;* to which valuable work we are indebted for some of the materials of this article. We have only to observe, that in the century between 1710 and 1810, the teas imported into this country amounted to upwards of 750 millions of pounds, of which more than 630 millions were sold for home consumption; between 1810 and 1828, the total importation exceeded 427 millions of pounds, being on an average, between 23 and 24 millions a year; and in 1831, the quantity imported was 26,043,223 pounds.

TEAK. A very valuable timber, which abounds in various parts of the East Indies, and is applied to domestic and nautical purposes. Ships built with teak are far more durable in the Indian seas, than those made of English oak.

TEAZLE. A plant, the heads of which are employed in the dressing of woollen cloth, and for which operation no substitute equally effective has hitherto been discovered. The teazle has been considered as affording almost a solitary instance of a natural production being applied to mechanical purposes in the state in which it is produced. It appears, that many attempts have been made to supply a substitute for the teazles, by art, all of which have been abandoned as defective or injurious. The use of the teazle is to draw out the ends of the wool from the manufactured cloth, so as to bring a regular pile or nap upon the surface, free from twistings and knottings, and to comb off the coarse and loose parts

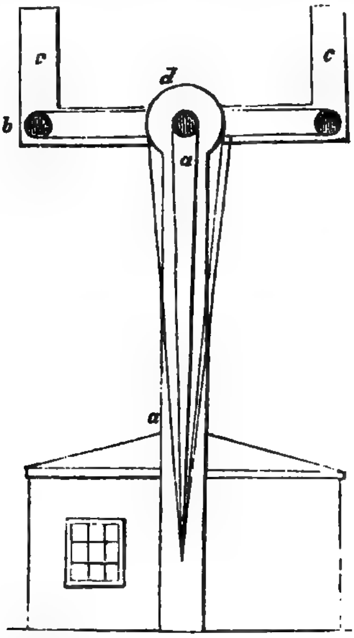
wool. The head of the true teazle is composed of incorporated flowers, separated by a long ridgy chaffy substance, the terminating point of which ...ished with a fine hook. Many of these heads are fixed in a frame; and ...ese the surface of the cloth is teazed or brushed, until all the ends are drawn ...he loose parts combed off, and the cloth yields no impediment to the free ...e of the wheel or frame of teazles. Should the hook of the chaff, when ..., become fixed in a knot, or find sufficient resistance, it breaks, without ...ng or contending with the cloth; and care is taken, by successive applications, ...w the impediment out; but all mechanical inventions hitherto made use ...r resistance to the knot; and, instead of yielding and breaking, as the ...does, resist and tear it out, making a hole, or injuring the surface. The ...g of a piece of cloth consumes from 1500 to 2000 heads, when the ...s completely finished: they are used repeatedly in different stages of the ...s.

...LEGRAPH. The name given to a machine, by which intelligence may ...smitted, with extraordinary rapidity, to great distances. There is reason ...ve, that the principle of the modern invention of communicating inform... by means of signals, is of great antiquity. The moderns have, however, ...rit of applying the principle, so as to render it a scientific, and almost ... machine. Polybius described a very complete arrangement of signals ...ns of torches. The Marquess of Worcester, in his *Century of Inven-* ...boasts of being able to do wonders in this way, as he was wont to do in ... Dr. Hook, whose genius as a mechanical inventor was perhaps never ...ed, delivered a "*Discourse to the Royal Society, on the 21st of May*, 1684, ...*a way how to communicate one's mind at distances*" of 30, 40, 100, and ...des, &c. "in as short a time almost as a man can write what he would ...ent." In this discourse, which was published in Derham's *Collections* ... *Experiments and Observations*, the Doctor takes to his aid the then ...invention of the telescope, and explains all the details of the method by ...characters exposed at one station, may be rendered plain and distinguish... the others.

...t sixteen years afterwards, Amontons proposed the construction of tele... in France; which much resembled Dr. Hook's. The method was as ...:—

...there be people placed in several stations, at a certain distance from one ..., that, by the help of a telescope, a man in one station may see a signal ...n the next before him: he must immediately make the same signal, that ...be seen by persons in the station next after him, who are to communi... to those in the following station, &c. These signals may be as letters ...alphabet, or as a cypher, understood only by the two persons who are in ...tant places, and not by those who make the signals. The person in the ...station making the signal to the person in the third, the very moment ...it in the first, the news may be carried to the greatest distance in as ...ne as is necessary to make the signals in the first station. The distance ...several stations, which must be as few as possible, is measured by the ...f a telescope. Amontons tried this method in a small tract of land, ...several persons of the highest rank, at the court of France. It was not, ...r, till the French revolution, that the telegraph was applied generally to ...purposes. Whether M. Chappe, who is said to have invented the tele... first used by the French, about the end of 1793, knew any thing of ...n's invention or not, it is impossible to say; but his telegraph was con... on principles nearly similar. The manner of using his telegraph was ...ws:—At the first station, which was on the roof of the palace of the ... at Paris, M. Chappe, the inventor, received in writing, from the Com... of Public Welfare, the words to be sent to Lisle, near which the French ... that time was. An upright post was erected on the Louvre, at the top ... were two transverse arms, movable in all directions by a single piece ...anism, and with inconceivable rapidity. He invented a number of ... for these arms, which stood as signs for the letters of the alphabet; ...e, for the greater celerity and simplicity, he reduced as much as possible. ...mination will easily conceive that sixteen signs may amply supply all

the letters of the alphabet, since some letters may be omitted, not only detriment, but with advantage. These signs, as they were arbitrary, c changed every week; so that the sign of B, for one day, might be the M, the next; and it was only necessary that the persons at the ext should know the key. The intermediate operators were only instructe rally in these sixteen signals; which were so distinct, so marked, so di the one from the other, that they were easily remembered. The cons of the machine was such, that each signal was uniformly given in preci same manner at all times; it did not depend on the operator's manu and the position of the arm could never, for any one signal, be a degree or a degree lower,—its movement being regulated mechanically. M. having received at the Louvre the sentence to be conveyed, gave a signal to the second station, which was Mont Martre, to prepare. A station there was a watch-tower, where telescopes were fixed, and the on watch gave the signal of preparation which he had received; and th municated successively through all the line, which brought them all into of readiness. The person at Mont Martre then received, letter by lett sentence from the Louvre, which he repeated with his own machine; a was again repeated from the next height, with inconceivable rapidity, final station at Lisle. The first description of the telegraph was brough Paris to Frankfort-on-the-Maine, by a former member of the Parliam Bourdeaux, who had seen that which was erected on the mountain of B As given by Dr. Hutton, it is as follows:—



a a is a beam or mast of wood, placed upright on a rising ground, whi about fifteen or sixteen feet high. *b b* is a beam or balance, moving upo centre *a a*. This balance-beam may be placed vertically, or horizontall anyhow inclined, by means of strong cords, which are fixed to the whe on the edge of which is a double groove, to receive the two cords. This ba is about eleven or twelve feet long, and nine inches broad, having at the two pieces of wood *c c*, which likewise turn upon angles, by means of other cords that pass through the axis of the main balance—otherwise

ance would derange the cords; the pieces C are each about three feet long, may be placed either to the right or left, straight or square, with the ance-beam. By means of these three, the combination of movement is very ensive, remarkably simple, and easy to perform. Below is a small wooden , in which a person is employed to observe the movements of the machine. the eminence nearest to this, another person is to repeat these movements, a third to write them down. The time taken up for each movement is nty seconds, of which, the motion alone is four seconds; the other sixteen machine is stationary. Two working models of this instrument were exe- ed at Frankfort, and sent by Mr. W. Playfair, to the Duke of York; and ce, the plan and alphabet of the machine came to England.

Various experiments were in consequence tried upon telegraphs in this ntry; and one was soon after set up by government, in a chain of stations the Admiralty-office to the sea coast.

his telegraph consisted of six octagonal boards, each of which was poised a horizontal axis in a frame that surrounded it, in such a manner that octagonal board might be placed either with its flat side towards the spec- , or edgeways, when the board became invisible owing to the distance. An er's cabin was placed underneath, provided with a telescope pointed to the station. By a simple mode of working, these six boards made 36 changes, ich are adequate for all occasions. Experience has shown that this plan of graph, which was deemed at the time of its introduction to be an improve- nt upon the design of M. Chappe, previously described, was, in reality, in- r to it in simplicity and clearness; consequently the latter has been since pted by the British government, under such improved modifications as t practical conversancy in the subject must necessarily produce.

here is probably no subject which has exercised more of the ingenuity of ntific men than that of telegraphic communication; and we are convinced a description of the various schemes for that object, would alone fill a volume the present. We shall therefore confine our notice to a very few of them, in preference, to such as are upon a totally different principle from each r.

Telegraphic communication, (the ingenious Mr. Vallance observes,) has erto been a mean of intercourse that was serviceable only during those ions of the enlightened half of the twenty-four hours, when clear weather itted of uninterrupted vision for a distance of about ten miles. It has been uently proposed to remedy this disadvantage, (so far as related to the absence ght, that is,) by nocturnal telegraphs, for the lamps of which, gas seemed dmirably adapted. But as this would do nothing towards lessening the in- uption which wet and foggy weather occasion, it has not been thought worth le to incur the expense of it; and as it has also been supposed impossible these interruptions could be obviated, we have sat down under the impres- , that communications, rapid as are those of the telegraph under favourable umstances, must remain dependent, to a degree that would ever prevent the ciple from being rendered available to the purposes of commercial and do- tic communication. But this impression is erroneous,—there being a well wn principle, by the aid of which information may be communicated equally during darkness and the most foggy weather, as in daylight and clear wea . The putting of this principle into execution, will of course be incompar- more expensive than laying down a line of telegraphs; but as the revenue y be made to bring in will, (to use M. Dupin's observation relative to our estic policy,) render this expenditure but an additional instance of that "eco- y, well understood, which knows how to make sacrifices bordering almost on igality, in order to reap afterwards, with usury, the fruits of its advances," amount of it in no wise diminishes the attention the principle deserves.

"It has long been known," adds Mr. Vallance, "that an incompressible d, confined in a pipe, might be caused to move through the whole length hat pipe, by operating on it at either end, whether the pipe was one mile or hundred miles long. (It was proved by Bossuet, for a distance of three s, about half a century ago.) But although this has long been known, although it offers a mean of symbolic intercourse which would alike be inde-

pendent both of darkness and cloudy days, yet it has been unthought of as a principle of instantaneous transmission." The mode proposed by Mr Vallance, of carrying the principle into practice, may be thus briefly explained.

A pipe of small calibre is to be laid from one to the other of the places, between which, (as hitherto termed,) telegraphic communication is to be effected. This pipe, (effectually secured against leakages,) is to be kept constantly filled with water, by apparatus which both empties it of air and guards against (or rather counteracts) contraction and expansion. Each end of this pipe is connected to apparatus, which will cause any movement of the water inside it, to act on and move a hand. This hand may point out and indicate letters, or numbers, or words, painted on a dial plate; though it will be better to cause it to indicate them when placed in a line. In connexion with telegraphic apparatus, is always understood a vocabulary, connecting the symbols with certain meanings. The principle of this method will admit of either letters, numbers, words, or sentences, being used. Having thus explained the principle of Mr. Vallance's plan we must refer the reader for the details of it to a pamphlet by the author, published by Wightman, London, 1825, entitled, *Description of a Method of Telegraphic Communication.* A variety of suggestions for the employment of the electric fluid acting upon wires extended from the places in communication, have been made from time to time. In one of these the intelligence is communicated by means of *sound*, produced by the collision of bodies in opposite states of electricity; these bodies consist of a series of small balls, suspended at the extremities of metallic conductors by slender chains, and a series of numbered bells hung within their space of action. The author of this plan, who is an anonymous contributor to a scientific journal, illustrates his proposed scheme by the following example:—

"Let a metallic wire, coated with a non-conducting substance, be extended under ground between any two given places, which, for the sake of experiment, may be two separate apartments in the same house; one of which may be denominated A, and the other B. In the apartment A place an electrical machine, and to the extremity of the wire in B a little ball, suspended by means of a very slender chain, within whose sphere of action there is a common bell. Now, by connecting the wire in A with the conductor of the machine, the electric fluid will pass instantaneously along it, and charge the ball in B, through the medium of its little chain, which flies off immediately to the uninsulated bell, to discharge its surplus of electric matter, and recover its equilibrium. The force by which it is attracted or impelled towards the bell is quite sufficient to produce the sound required; it is an experiment which I have often made, and with invariable success. Let this bell be numbered 1, and have a series of them up to 10, with separate and distinct metallic conductors, it is evident to a demonstration that, by a combination and the successive excitement of these simple numbers, the whole of those at present made use of in our most improved telegraph and signal books, together with their corresponding meanings, may be conveyed from the apartment A to B with the greatest accuracy, and with the speed of thought.

"Thus, by this simple and inexpensive means, (by two electrical machines and a double series of wires with their appendages,) say between Portsmouth or Plymouth and London, news of the greatest political importance may be conveyed in a few minutes, by a gentleman connected with the apparatus at either of these places; he has only to excite the wires which correspond to each individual number of the telegraph made to him by the common flag signals which will, in almost the same instant of time, affect their corresponding in London, and give the necessary intelligence in a series of numbers, whose symbols will be found by referring to the signal books now in use.

Domestic telegraphs (which are now very common) are designed to prevent the trouble of calling for certain articles in a dwelling-house, and to dispense with one-half of the journeys of the servants in answering bells. They are made in a variety of ways, but usually consist of two circular indexes or dials, equally divided into a given number of parts, and marked on these divisions, with the names of such things or necessaries as are generally wanted in a house, such as dinner, tea, supper, coals, lights, carriage, horse, &c. These indexes exactly

nd are provided with hands, the axes of which pass through
ual diameter; a wire or chain extends from the pulley of one of
the sitting room, to another fixed in the kitchen, or servants' hall.
f the latter contains a spring, and that of the former a ratchet
tch, so that if the hand of the sitting room index be turned, it
at of the servants' room an equal portion of a revolution, and
to the same word. The pull is lifted off the ratchet after it is
ing a pin, when the spring in the other pulley draws the chain or
and so returns both the hands to their original place at *o*. The
e servant is called by the ringing of a bell.

PE. An optical instrument, employed for discovering and view-
jects; or which magnifies their natural appearance, by represent-
er a larger angle than that under which they appear to the naked
pes are divided into two general kinds, *refracting* and *reflecting*.
elescope consists of different lenses, through which the objects are
refracted by them to the eye. A *reflecting* telescope, besides lenses,
speculum within its tube, by which the rays proceeding from an
cted to the eye.

al effect of telescopes depends upon this rule, that objects appear
l, in proportion to the angle which they subtend to the eye; and
the same, whether the pencils of rays, by which the objects are
le to us, come directly from the objects themselves, or from any
to the eye, where they may have been united, so as to form an
object; because they issue again in certain directions from those
there is nothing to intercept them, in the same manner as they
corresponding points, in the objects themselves. In fact, there-
s effected by a telescope, is, first, to make an image of a distant
ans of a lens or mirror, and then to give the eye some assistance
hat image as near as possible; so that the angle which it shall
e eye, may be very large, compared with the angle which the
would subtend in the same situation to the naked eye. This is
eans of an eye-glass, which so refracts the pencils of rays, that
terwards be brought to their several *foci*, by the humours of

of refracting and reflecting telescopes have been frequently varied,
sometimes distinguished by the names of their inventors, as the
the *Newtonian* telescope; sometimes by the particular use for
e best adapted, as the "*land* telescope," the "*night* telescope,"
ical telescope," &c.

omical telescope consists of two convex lenses, A B. K M, each
xtremity of a different tube. One of the tubes is very short, as its
to adjust the focus in proportion to the distance of the object
it slides within the other. Contrary to the arrangement which
the microscope, the glass which has the longest focus, is presented
and therefore constitutes the object-glass. P R, respresents a very
, from every point of which rays come, so very little diverging to
K M of the telescope, as to be nearly parallel: *p r*, is the picture
P R, which would be formed upon a screen situated at that place.
place, the rays of every single radiant point proceed divergently to
A B, of greater convexity, and which causes the rays of each pencil

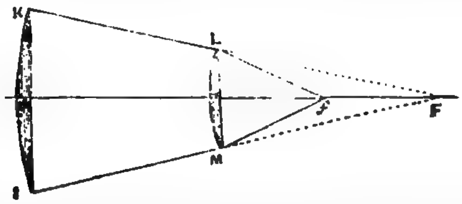
allel, in which direction they enter the eye at O. The axes of the
e coincident in the direction Q L O; L *q*, is the focal distance of
s, and E *q*, is the focal distance of the eye glass; consequently,

the distance between the two glasses is equal to the sum of their focal distances. An object viewed through this telescope, by an eye situated at O, will appear magnified and distinct, but inverted. The object seen without the telescope, will be, to its appearance, through the telescope, as q E to q L; that is, as the focal distance of the eye-glass, to the focal distance of the object-glass. For the pencils of rays, which, after their crossing at $r\, q\, p$, proceed divergently, fall upon the lens A B, in the same manner as if a real object were situated at $r\, q\, p$; and consequently, after passing through that lens, the rays of each pencil proceed parallel. To the eye at O, the apparent magnitude of the object P R, is measured by the angle B O A, or by its equal p E; but, to the naked eye at L, when the glass is removed, the apparent magnitude of the object is measured by the angle P L R, or by its equal r L p; therefore, the apparent magnitude to the naked eye, is to the apparent magnitude through the telescope, as the angle r L p, is to the angle p E r; or, as the distance q E, is to the distance q L.

If the angles r L p, and p E r, were equal to each other, the telescope would not magnify, and they would be equal, if the lenses were of equal focal distance. Hence, as the magnifying power of the telescope is produced by making the focal distance of the eye-glass less than that of the object-glass, it will easily be perceived, that the greater the difference of the focal lengths, the greater will be the magnifying power. It is found, however, that they may be so disproportionate, that the increased magnifying power is overbalanced by the indistinctness which ensues. In order, therefore, to obtain a great magnifying power with the preservation of just proportion, these telescopes have sometimes been made one hundred feet, or upwards, in length; and, as they were mostly used for astronomical purposes, they were frequently used without a tube. The object lens was fixed on the top of a pole, in a frame capable of being moved by a cord or wire, in any required direction, and the eye-glass, fixed in a short tube, was held in the hand, or fitted to another frame, about the height of the observer, so as to be capable of a simultaneous movement. A telescope of this description was called an *aërial* telescope. Its use was evidently very incommodious; but, such were the great pains taken by philosophers, in exploring the wonders which even the imperfect telescopes, at first constructed, promised to lay open, that with such an instrument, the five satellites of Saturn, and many other remarkable objects, were discovered.

The length of common refracting telescopes must be increased in the proportion of the square of the increase of their magnifying power; so that, in order to magnify twice as much as before, with the same degree of light and distinctness, the telescope must be lengthened four times; and to magnify three times as much, nine times. On this account, their unwieldy length, when great powers are desired, is unavoidable. The breadth of an object-glass adds nothing to the magnifying power; for, whatever the latter may be, the image will be equally formed at the distance of its focal length; but the *brilliancy* of the image will be increased by the breadth, as a greater number of rays will then diverge from every point of the image.

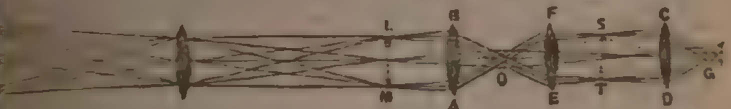
The magnifying power, and the field of view, of this telescope may be increased by using two plano-convex lenses, combined so as to act like one glass;



and such a combination is now generally employed. If two plano-convex lenses be used, the curvature of both conjointly, will be less than the curvature of a

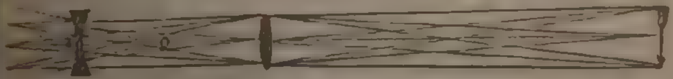
single lens of equal magnifying power; the combination therefore improves the eye-glass of a telescope, because the aberration of the rays passing through it will be less than through a single lens of the same focus. Suppose I K to be a plano-convex lens, of which the focus is at F, so that an object placed at F would be seen magnified through it. If another lens L M, be placed between the first lens and its focus, the focus of the rays passing through both will be shortened, and will fall at about the distance *f*, so that, when thus combined, they will act like a single lens of much greater curvature. The telescope called a *night-glass*, is simply a common astronomical telescope with tubes, and made of a short length, with a small magnifying power. It generally magnifies from 6 to 10 times. It is used by navigators at night, for the purpose of discovering objects that are not very distinct, such as vessels, coasts, rocks, &c. From the smallness of its magnifying power it admits of large glasses being used, and consequently has a well-enlightened field of view.

The astronomical telescope, by the use of two additional eye-glasses, shows objects in their right position, and becomes a *terrestrial* or *land* telescope; and is sometimes called a *perspective* glass. This telescope is shown by the following cut. The rays of each pencil coming from the image L M, of the object



I K, emerge parallel from the lens A B, and having crossed at its focus O, they continue in that direction to the lens E F; in consequence of which they form an image S T, at the focus of the second lens, and again diverging, they fall upon the third lens C D, in the same manner as they did upon the the lens A B; therefore after their emergence from this last lens, they fall parallel upon the eye at G. But as the last image S T, is not inverted as at L M, but in the same position as the object I K, the eye sees a true or upright picture, as if the rays had come directly from the object. The last lens, or the one nearest the eye, is now generally made of two plano-convex lenses, instead of a double convex one. By this means, all the best terrestrial telescopes contain four lenses in the tube next the eye.

The telescope of the celebrated Galileo consists of a convex object-glass, and a concave eye-glass, as represented by the following cut. The distance between the two lenses is less than the focal distance of the object-glass; but the concave glass is situated so as to make the rays of each pencil fall parallel upon the eye, as is evident by conceiving the rays to go back again through the eye-glass towards O: E O being the focal length of the eye-glass. The field of view of the Galilean telescope does not depend, as in those with convex glasses, upon the size of the eye-glass, but upon the breadth of the pupil of the eye: because the lateral pencils of rays diverge from the axis of the eye-glass after their emergence from it. On this account, the eye should be placed as near the eye-glass as possible, in order that it may receive the greatest number of



pencils. No nearness of the eye, however, will wholly prevent the field of view from being more confined than with convex eye-glasses of equal curvature; but this disadvantage is counterbalanced by the valuable property of superior distinctness.

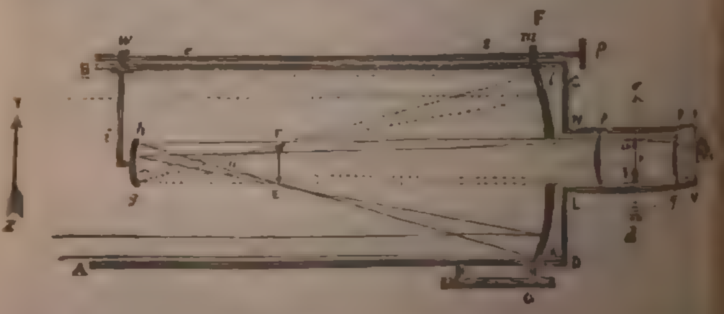
The telescopes which we have hitherto described will only bear a small aper-

ture, without exhibiting circular prismatic rings of colours, which are detrimental to their utility. Two causes contribute to this effect. 1. Spherical surfaces do not refract the rays of light accurately to a point; and 2. The rays of compounded light being differently refrangible, come to their respective force at different distances from the lens; the more refrangible rays converging sooner, of course, than the less refrangible. If the image of a paper painted entirely red, be cast, by means of a lens, upon a screen, it will be formed at a greater distance than the image of a blue paper cast by the same lens. The image of a white object is composed of an indefinite number of coloured images, the violet being the nearest, and the red the farthest from the lens; and the images of intermediate colours at intermediate distances. The whole image is therefore in some degree confused, though its extremities are most so; and this confusion being increased, not only by the magnifying power of the eye-glass, but also by the dispersive power which it has in common with the object-glass, the necessity for a certain proportion between the powers of the object and the eye-glass becomes indispensable

The late Mr. John Dolland, by making a compound lens of three different substances, of different refrangible powers, the rays of light which were too much dispersed by one convex lens, were brought nearer to a union with each. The telescopes made with an object-glass of this kind are now commonly used, and are distinguished by the name of *achromatic* telescopes, a term which signifies *colourless*. The object-glasses of Dolland's telescopes are composed of three distinct lenses, two of which are convex, and the other concave. The achromatic effect may be produced by the union of one convex and one concave lens, but not so perfectly as with three lenses.

The impossibility, however, of obtaining perfectly homogeneous glass, and the consequent failure of producing that complete correction of the aberration of the rays of light in the telescopes called achromatic, induced Dr. Blair to try the effects of *fluid* mediums; and his success was such as to induce him to give the term *aplanatic*, or *free from error*, to the object lenses he thus constructed. He made a compound lens, consisting of a plano-convex of crown glass, with its flat side towards the object, and a miniscus of the same material, with its convex side in the same direction, and its flatter concave next the eye, and the interval between the lenses be filled with a solution of antimony in a certain proportion of muriatic acid. The lens thus constructed did not exhibit the slightest vestige of any extraneous colour; but the invention, after a lapse of more than twenty years, has not come into general use, probably from the difficulty of preserving any fluid from growing turbid in the course of time.

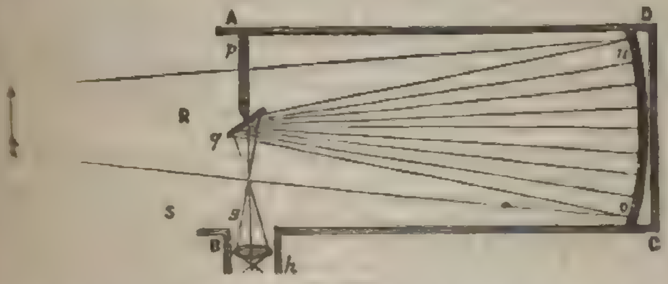
Of reflecting telescopes, the Gregorian is the one most generally used. The construction of this instrument is represented below.



At the bottom of the tube A B C D, is placed the large concave reflector D, with a circular hole through the middle of it, in the direction of its axis. Within the tube of the telescope, and directly facing the perforation, is placed

the small concave speculum $g\ h$, supported by the arm i. Two lenses, $t\ t$ and $q\ q$, are contained in the eye-tube L M N O, and the observer applies his eye to a small hole at f, in order to view the magnified image of the distant object Y Z. The large reflector $k\ l$ receives the rays from the distant object, and reflects them to its focus, where they form an inverted image E F. Diverging from the points of union, the pencils of rays proceed onwards, and cross each other a little before they reach the small mirror $g\ h$: the focus of which is at n, or a little further from the large speculum, than its principal focus. From the small mirror, the rays are reflected somewhat convergently, and in that state are received before they meet a plain convex lens $t\ t$. By the action of this lens, their convergency is increased, and they form a second image, $a\ b$, which is erect like the object. This second image is magnified by the lens $q\ q$, through which the rays of each pencil pass nearly in a parallel direction to the eye. To exclude all extraneous light, the eye is applied to a small hole, and sees the image under the angle $c\ f\ d$. If the lens $t\ t$ were removed, the image would be formed somewhat larger at r, but the area, or field of view, would be smaller and less pleasant, for which reason it is not usual to omit the second lens. In this, and other reflecting telescopes, containing two curved reflectors, it is necessary to have the power of altering the distance between the two mirrors. This is usually done by a wire, $e\ s$, passing along the outside of the tube and with a screw at the end of it, which works in an external projection w, of the arm i, within the tube. The other end of the wire passes through a small stud affixed to the tube of the telescope at m; and the observer, while looking through the hole at f, turns the milled head p, of the wire, which is near him, and thus regulates the distance of the small speculum, as he finds requisite.

A section of the Newtonian Reflecting Telescope is shown below.



A B C D, is the tube, which is open at the end A B, opposite the large speculum $n\ o$. The large concave speculum $n\ o$, is not perforated as in the Gregorian telescope, but the small speculum q, is set aslant, so as to direct the rays received from the large speculum, through an aperture g, at the side of the tube, where they are received and refracted to the eye by a lens or lenses in a tube h. The speculum q, is suspended within the tube, by an arm p, with its centre opposite the centre of the speculum $n\ o$; it is not curved, but plane, and has therefore no other effect than that of changing the direction of the rays. Without the small reflector, the rays from the large speculum would be converged at R, and the observer might have an eye-glass placed to view the image formed there, with his face towards the speculum $n\ o$; but in this case his head would intercept the greater part of the rays, unless the instrument were very large. The Newtonian telescope, as first described, is very convenient for viewing objects in the zenith; as they may be seen while the observer retains his ordinary position of looking forward horizontally.

The best and most powerful reflecting telescopes, however, which have ever been constructed, are those of Dr. Herschel, who is so well known by his labours, as one of the most eminent astronomers of the present day. The largest reflecting telescope made by Dr Herschel, is forty feet in length, and

the polished surface of the large speculum is four feet in diameter. It has no second reflector; a circumstance that adds much to the brightness of the objects viewed in it. The observer, who looks through an eye-glass, as in other telescopes, has, of course, his back to the object; but it is so contrived that little or no light is intercepted by this means. We may use the foregoing diagram of the Newtonian telescope, on page 773, to illustrate the position of the observer, by this telescope, more particularly. Supposing the speculum *q*, and its support to be removed, the rays *n o*, as before observed, would be converged at R; but if the observer were placed there, he would intercept a large portion of the light, even when facing this gigantic telescope. Supposing the upper part *n*, of the speculum, to be inclined downwards, that is, to be set at an angle to the axis of the tube, the rays may be directed to S, or any other point nearer the tube, where the spectator may be placed, and will occasion no sensible dimness of the image thrown by the large mirror. In Dr. Herschel's large telescope, the converging rays reflected by the mirror pass the extremity of the tube, at the distance of four inches from it, and come into the air; by this means the observer scarcely at all interferes with the incident light, as the diameter of the tube exceeds that of the mirror, by about ten inches. The mirror has a magnifying power of six thousand times the diameter of an object.

TELLURIUM. A metal discovered by Klaproth in 1798, in an ore of gold from Transylvania. It has a silver-white colour, and possesses much brilliancy. Its texture is laminated like antimony, and has a specific gravity of 6.115. It is very brittle, may be easily reduced to powder, and melts at a temperature a little higher than lead does. If the heat be increased a little above the fusing point, it boils and evaporates, and attaches itself in brilliant drops on the upper part of the retort in which the experiment is made; it is, therefore, next to mercury and arsenic, the most volatile of the metals. It combines with oxygen only in one proportion, forming therewith a compound possessing acid properties.

TEMPERATURE. Implies that degree of sensible heat, which a body possesses when compared with other bodies. To accurately measure and determine such degrees of heat, so as to be readily comprehended, thermometers have been constructed; in which some universally understood degree of heat, as that of boiling water, is made the basis of the calculation for all other temperatures.

TEMPERING. The art of altering the existing degree of elasticity in metals. See Iron.

TENACITY. A term derived from the Latin, implying the property of holding fast, firmness, &c.; some authors restrict its application to that force by which metals resist their being pulled, or torn asunder; as the action of a weight suspended to the end of a wire; and make a distinction between it, and the term *cohesion*, which of course implies that force by which the parts of bodies cohere. The real distinction, if any, is however so refined, that we may without much impropriety treat them here as the same force.

The tenacity or cohesion of solids is measured by the force required to pull them asunder; and authors on the subject in general agree, that it may be *calculated from the transverse strength* of the bar or rod, as near, or perhaps nearer to the real cohesion, than can be obtained by pulling the body asunder; but we find that this assertion, however correct it may apppear from abstract reasoning, is at variance with the most prominent facts derived from actual experiment, and given by the same authors. By the experiments of Emerson, it is stated that a wire of iron, one-tenth of an inch in diameter, requires a force of 450lbs. to pull it asunder; and according to Rumford, that an inch cylinder or rod of iron, required a pull of 63,320lbs. to break it. Now the area of transverse section of the inch rod is 785; in other words, it contains 78 wires of one-tenth of an inch in diameter; therefore the aggregate strength of the 78 wires, ought according to the doctrine laid down, to be equal to 63,320lbs.; but 78 × 450, make only 35.100; and thus it appears that calculation by the transverse strength, taking the wire for our datum, gives us but little more than half the real tenacity of the inch rod; and if we were to take the inch rod for our datum of calculation, we find (78 ÷ 63,320 = 811¾

each wire should sustain a force of 811lbs. Indeed, rather more than this, for re further told, (and we do not dispute its general accuracy,) that "the cohesive of metals is much increased by wire-drawing, rolling, and hammering." *illustrations* of the correctness of a theory, we have thought it necessary to , as it might prove of very serious consequence, were an engineer (for ce) to construct a wire bridge, founded upon calculations of the given verse strength of a rod of iron. His only security, it appears to us, would prove, himself, the actual tenacity of the identical material he employs, not place much dependance upon the experiments of others; for, however ously the latter may have been conducted, or faithfully detailed, there is wide difference in the results of experiments made upon the same nal material, that it is only by a great number of experiments that any approximation to the truth can be obtained. Mr. John Rennie, who has laudably and ably exerted himself in this field of inquiry, found many discordant results as those we have detected. In a paper furnished to the Society, that engineer states, that it had been deduced from the experi- made by Reynolds, that the power required to crush a cubic quarter of h of cast iron was 448,000lbs. avoirdupois, or 200 tons; whereas, by the e of thirteen experiments made by Mr. Rennie, in cubes of the same the amount never exceeded 10,392lbs.=not 5 tons!

desire of obtaining some approximation, which could only be accom- d by repeated trials on the substances themselves, induced Mr. Rennie to take the following experiments.

e apparatus used for this purpose was a powerful lever of the second class; sisted of a flat bar of the best English iron, about ten feet long, one of the mities being formed into a rule-joint, by which it was attached to a stout short standard of wrought iron, that was bolted to a massive bed-plate of ron; the hole in the centre of the joint, and the pin which formed the um, were accurately turned, so as to move slowly and freely. The lever accurately divided on its lower edge, which was made straight in a line the fulcrum. A point or division was selected, at five inches from the m, at which place was let in a piece of hardened steel. The lever was ed by a weight, and in this state it was ready for operation. But, in to keep it as level as possible, a hole was drilled through a projection on d-plate, large enough to admit a stout bolt easily through it, which again prevented from turning in the hole by means of a tongue fitting into a sponding groove in the hole, so that, in order to preserve the level, it was necessary to move the nut, to elevate or depress the bolt, according to the f the specimen. But as an inequality of pressure would still arise, from ture of the apparatus, the body to be examined was placed between two of steel, the pressure being communicated through the medium of two of thick leather, above and below the steel pieces, by which means a equal contact of surfaces was obtained. The scale was hung on a loop of touching the lever in an edge only. At first a rope was used for the e weight, which indicated a friction of four pounds, but a chain ished the friction one half. Every movable centre was well oiled.

Mr. Rennie's experiments on the cohesive strength of cast iron, to resist ession, there were four kinds of iron used; *viz.* 1. Iron taken from the of a large block, whose crystals were similar in appearance and mag- to those evinced in the fracture of what is usually termed gun-metal. taken from a small casting, close-grained, and of a dull grey colour. n cast horizontally, in bars of three-eighths of an inch square, eight inches 4. Iron cast vertically, same size as last. These castings were reduced y on every side, to one quarter of an inch square; thus, removing the external coat, usually surrounding metal castings. They were all subjected uge; the bars were then presumed to be tolerably uniform. The weights were of the best kind that could be procured, and, as the experiment ed, smaller weights were used.

e have not space for detailing the particulars of each experiment, we d only the *average* results of them.

The experiments on cast iron, in cubes of one-eighth of an inch,—specific gra 7.033, gave 1439 lbs. avoirdupois, as the average force required to crush the

On specimens of the same iron, one-eighth of an inch square, and one-fo of an inch long, the average force required was 2116 lbs.

On specimens of the same thickness, but varying in length from one-hal an inch to one inch, the average result was 1758 lbs.

On cubes of a quarter of an inch of the same metal, gave 9773 lbs. as average result.

On one-fourth of an inch cubes, made from horizontal castings of spe gravity, 7.113 gave 10,114 lbs. as the average.

On one-fourth of an inch cubes, vertical castings, specific gravity 7.074, average was 11,136 lbs.

A prism, having a logarithmic curve for its limits, resembling a column, was one-fourth of an inch diameter, by one inch long,) broke with 6954 lbs.

The trials on prisms, of different lengths, one-fourth and one-half horizon gave 9414 lbs.

The same, vertical, gave 9982 lbs.

Horizontal castings, varying from three-eighths to six-eights of an inch × gave an average of 8738 lbs.

Vertical ditto, gave 8536 lbs.

Experiments on different Metals.

					lbs.
¼ × ¼	cast copper, crumbled with				7318
,,	fine yellow brass reduced	$\frac{1}{10}$	with 3213¼	lbs. with	10304
,,	wrought copper	$\frac{1}{16}$	3427¼		6440
,,	cast tin	$\frac{1}{16}$	552¼		966
,,	cast lead		¼		483

The experiments on the different metals gave no satisfactory results. Th difficulty consists in assigning a value to the different degrees of diminutio When compressed beyond a certain thickness, the resistance becomes enormou

Experiments on the Suspension of Bars.

The lever was used as in the former case, but the metals were held by nipper. They were made of wrought iron, and their ends adapted to receive the bars, which, by being tapered at both extremities, and increasing in diameter from the actual section, and the jaws of the nippers being confined by a hoop, confined both. The bars, which were six inches long, and one quarter square, were thus fairly and firmly grasped

	lbs.
¼ inch cast-iron, horizontal	1166
¼ ditto ditto, vertical	1218
¼ ditto cast-steel, previously tilted	8391
¼ ditto blister steel, reduced per hammer	8322
¼ ditto shear steel . . ditto	7977
¼ ditto Swedish iron . . ditto	4504
¼ ditto English iron . . ditto	3492
¼ ditto hard gun-metal, mean of two trials	2273
¼ ditto wrought copper, reduced per hammer	2112
¼ ditto cast copper	1192
¼ ditto fine yellow brass	1123
¼ ditto cast tin	296
¼ ditto cast lead	114

Experiments on the Twist of ¼ inch Bars.

To effect the operation of twisting off a bar, another apparatus was prep It consisted of a wrought-iron lever, two feet long, having an arched head

-sixth of a circle, of four feet diameter, of which the lever represented the ius; the centre, round which it moved, had a square hole made to receive end of the bar to be twisted. The lever was balanced as before, and a scale ıg on the arched head; the other end of the bar being fixed in a square hole piece of iron, and that again in a vice. By this apparatus, quarter of an h bars, from horizontal castings, were twisted with weights in the scale, ave- ing 9 lbs. 15 oz. The vertical castings took 10 lbs. 10 oz. as an average.

On different Metals.

	lbs.	oz.	
Cast steel	17	9	in the scale.
Shear steel	17	1	
Blister steal	16	11	
English iron, wrought	10	2	
Swedish iron, wrought	9	8	
Hard gun-metal	5	0	
Fine yellow brass	4	11	
Copper, cast	4	5	
Tin	1	7	
Lead	1	0	

On Twists of different Lengths.—Horizontal.

	lbs.	oz.	
¼ by ½ long	7	3	weight in scale.
¼ by ¾ ditto	8	1	
¼ by 1 inch ditto	8	8	

Vertical.

	lbs.	oz.
¼ by ½ ditto	10	1
¼ by ¾ ditto	8	9
¼ by 1 inch ditto	8	5

Horizontal twists of quarter of an inch bars, at six inches from the bearing, ok an average of 9 lbs. 12 oz. in the scale.

Twists of ¼ inch square Bars, cast horizontally.

	qrs.	lbs.	oz.	
¼ close to the bearing	3	9	12	end of the bar hard.
¼ ditto	2	18	0	middle of the bar.
¼ at 10 inches from bearing, lever in the middle	1	24	0	

On Twists of different Materials.

These experiments were made close to the bearing, and the weights were cumulated in the scale, until the substances were wrenched asunder.

	lbs.	oz.	
Cast steel	19	9	weight in scale.
Shear steel	17	1	
Blister steel	16	11	
English iron, No. 1.	10	2	
Swedish iron	9	8	
Hard gun-metal	5	0	
Fine yellow brass	4	11	
Copper	4	5	
Tin	1	7	
Lead	1	0	

Miscellaneous Experiments on the Crush of 1 cubic inch.

	lbs. avoir
Elm	1284
American pine	1606
White deal	1928
English oak, mean of two trials	3860
Ditto, of five inches long, slipped with	2572
Ditto, of four inches long, slipped with	5147
A prism of Portland stone, two inches long	805
Ditto, statuary marble	3216
Craig Leith	8688

In the following experiments on stones, the pressure was communicated through a kind of pyramid, the base of which rested on the hide leather, and that on the stone. The lever pressed upon the apex of the pyramid. The cubes were of one and a half inch.

	Spec. grav.	lbs. av.
Chalk		1127
Brick, of a pale red colour	2.085	1265
Roe-stone, Gloucestershire.		1449
Red brick, mean of two trials	2.168	1817
Yellow-faced baked Hammersmith paviours three times		2254
Burnt ditto, mean of two trials		3243
Stourbridge, or fire brick		3864
Derby grit, a red friable sandstone	2.316	7070
Ditto, from another quarry	2.428	9776
Killaly white freestone, not stratified	2.423	10264
Portland	2.428	10284
Craig Leith, white freestone	2.452	12346
Yorkshire paving, with the strata	2.085	12856
Ditto, against the strata	2.507	12856
White statuary marble, not veined	2.760	13632
Branley Fall sandstone, near Leeds, with strata	2.506	13632
Ditto, against the strata	2.506	13632
Cornish granite	2.662	14302
Dundee sandstone or brescia, two kinds	2.530	14918
A two-inch cube of Portland	2.423	14918
Craig Lieth, with the strata	2.452	15560
Devonshire red marble, variegated		16712
Compact limestone	2.584	17354
Peterhead granite, hard, close-grained		18636
Black compact limestone, Limerick	2.598	19924
Purbeck	2.599	20610
Black Brabant marble	2.697	20742
Very hard freestone	2.528	21254
White Italian veined marble	2.726	21783
Aberdeen granite, blue kind	2.625	24556

N.B.—The specific gravities were taken with a delicate balance, made by Creighton, of Glasgow, all, with the exception of two specimens, which were by accident omitted.

Remarks.—In observing the results presented by the preceding table, it will be seen that little dependence can be placed on the specific gravities of stones so far as regards their cohesive powers, although the increase is certainly in favour of their specific gravities. But there would appear to be some undefined law in the connexion of bodies, with which the specific gravity has little to do. Thus, statuary marble has a specific gravity above Aberdeen granite, yet

ɔt much above half the latter. Again, hardness is not altogether ᶠ strength, inasmuch as the limestones, which yield readily to nevertheless a cohesive power approaching to granite itself.

made on the transverse strain of Cast Bars, the ends loose.

	Weight of the bars lbs.	oz.	Distance of bearings ft.	in.	lbs. av.
h square	12	6	3	0	897
ch ditto	9	8	2	8	1086
›ve bar			1	4	2320
h square through the dia-	2	8	2	8	851
ve bar			1	4	1587
hes deep, by ½ inch thick	9	5	2	8	2185
›ve bar			1	4	4508
:s deep, by ⅓ inch thick .	9	15	2	8	3588
›ve bar			1	4	6854
;, by ¼ inch thick	9	7	2	8	3979
:riangles, with the angles up wn, viz., with the edge or p	9	11	2	8	1437
gle down	9	7	2	8	840
.t bar			1	4	3059
:ond bar			1	4	1656
:dged bar was cast, whose ions were 2 inches deep ide, edge up	10	0	2	8	3105

se bars contained the same area, though differently distributed

ıade on the Bar of 4 inches deep by ¼ inch thick, by giving it rent forms, the bearings at 2 feet 8 inches, as before.

	lbs.
into a semi-ellipse, weighed 7 lbs	4000
olic on its lower edge	3860
ıches deep by ¼ inch thick	3979

n the transverse strain of Bars, one end made fast, the weight ıended at the other, at 2 feet 8 inches from the bear ing.

	lbs.
ıare bar bore	280
hes deep by ½ an inch thick	539
·, the ends made fast	1173

.cal experiment of Emerson was tried, which states, that by ·rtion of an equilateral triangle, (see page 114 of Emerson's bar is stronger than before; that is, a part stronger than the ıds were loose at two feet eight inches apart, as before. The ı the part was intercepted was lowermost; the weight was ap- ɜ above; it broke with 1129 pounds, whereas in the other case pounds.

				lbs.	
·nth inch diameter of	*Lead*	breaks with	.	29¼	Emerson.
do.	*Tin*	do.	.	49¼	„
do.	*Copper*	do.	.	299¼	„
do.	*Brass*	do.	.	360	„

					lbs	
A wire of one-tenth inch	diameter of	*Silver*	breaks with	.	370	Emerson
Do.	do.	*Iron*	do.	.	450	"
Round bar, 1 inch	do.	"	do.	.	63320	Rumford

The relative cohesive strength of the metals are, according to Sickengen, as follow :—

Gold	150,955
Silver	190,771
Platina	262,361
Copper	304,696
Soft Iron	362,927
Hard Iron	559,880

But their hardness, according to Cavallo, follows this order, viz., Iron, Platinum, Copper, Silver, Gold, Tin, Lead

Banks observes that iron is about four times as strong as oak, and six times as strong as deal. Wood is from seven to twenty times weaker transversely than longitudinally. It becomes stronger both ways when dry.

TENON. The end of a bar of metal or piece of wood reduced in its dimensions, so as to fit a hole in another piece, called a mortise, and thus joining the two together.

TENSION. Is the state of a thing stretched; this term is much used by engineers to express the tenacity of metals and other substances, when pulled in the direction of their length; thus a wire of one-tenth of an inch in diameter, is said to be capable of resisting a tension of 450 pounds.

TENTER, *trier*, or *prover*, a machine or frame, used in the cloth manufactory, to stretch out the pieces of cloth, and make them set even and square. It is usually about 4½ feet high, and for length exceeds that of the longest piece of cloth. It consists of several long square pieces of wood, placed like those which form the barriers of a menage; so, however, as that the lower cross pieces of wood may be raised or lowered, as is found requisite, to be fixed at any height, by means of pins. Along the cross pieces, both the upper and the lower one, are numerous sharp hooked nails, called tenter-hooks, on which the selvages of the cloth are hooked.

TESSELLATED PAVEMENTS. Pavements of different coloured stones, tiles, or brick, laid chequer-wise, or like dice (tesselæ.) The term tessellated is, however, extended to all kinds of mosaic patterns or designs.

TEST. Any solid or fluid body, which, added to a substance, teaches us to distinguish its chemical nature or composition.

THEATRE. An edifice or great room for the public exhibition of scenic representations, the performance of the drama, of concerts, the delivery of scientific lectures and demonstrations, &c. Considering that the description of a theatre for the latter purpose will not be out of place in this work, and be acceptable to our readers, we shall here annex an account of the lecture theatre of the London Mechanics' Institution; which may serve the purpose of a model whereon similar undertakings may be constructed and arranged, making such alterations and modifications as will better adapt them to other circumstances.

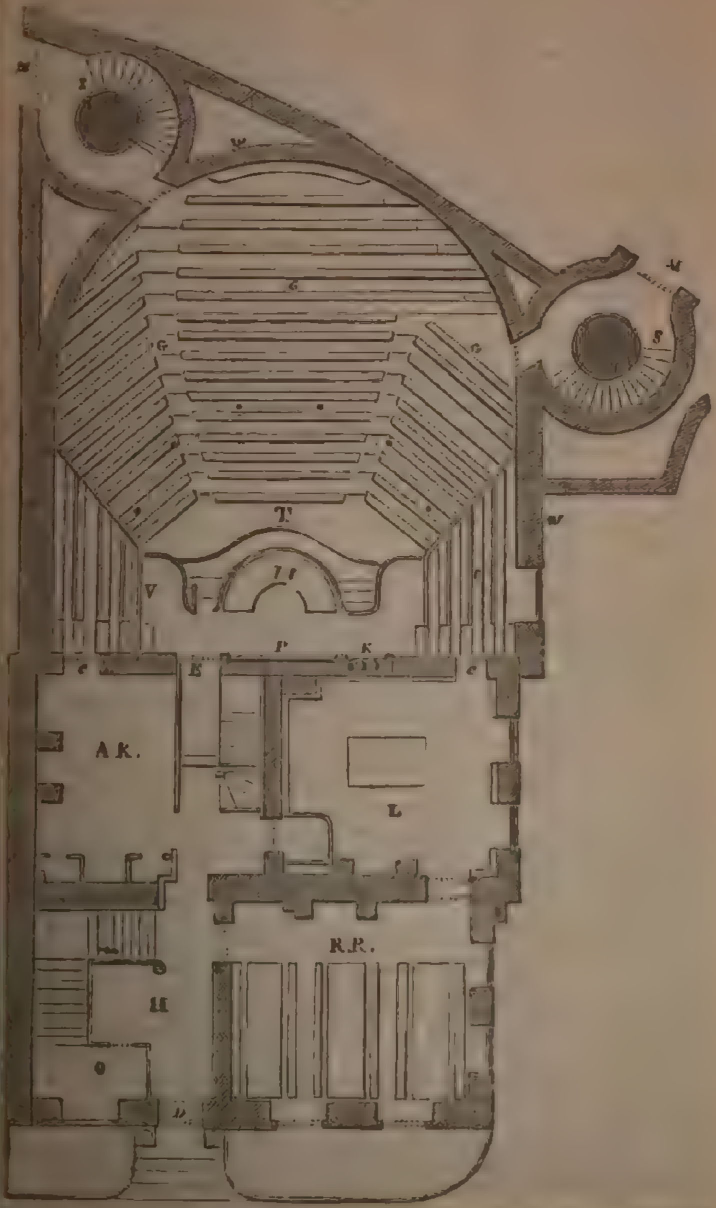
The front of this institution is a large dwelling-house, situated in Southampton Buildings, at the corner of Staple's Inn, in Holborn; the lower rooms of which are employed for the library, reading-rooms, apparatus rooms, laboratory, &c., and the upper as the private apartments of the Secretary. The theatre is an entirely new structure, built at the back of, and in connexion with, the house. The first stone of the theatre was laid on the 2d December, 1824, by Dr. Birkbeck, the munificent patron and enlightened president of the institution, and it was opened for use on the 8th of July, 1825.

The annexed *Fig.* 1 exhibits a plan of the ground floor of the whole building, on a scale of 1 inch to 20 feet.

The doors in front of the house in Southampton Row are represented at D. O, office. H, hall and principal staircase. R R, reading-room for the accommo-

lation of the members, supplied with all the periodical journals and reviews, and where all the books in the library may be perused. L, the library, containing upwards of 5000 volumes; including almost every work of reputation on

Fig. 1



science and literature, which may either be consulted in the reading-room, or taken home by the members. A R, ante-room to theatre. E, principal entrance from the house into theatre. *e e*, side-entrances into theatre. T, the theatre, bounded by a wall *w w w*, of a horse-shoe form. G G G are the seats appropriated to the members in general. C are those allotted exclusively to members of the committee; and V, those for the accommodation of honorary members, and visitors. N is the entrance into the theatre from Northumberland Court; and M is that leading from Middle Row, Holborn. S S, two circular spiral staircases, which proceed from the basement to the gallery. *l t* is the lecturers' table, behind which, at P, is a large frame for the exhibition of plans, diagrams, charts, drawings, &c.; and when these are made into transparencies, they are illuminated by a series of gas jets arranged behind the frame. F is a furnace, employed in the chemical lectures. This furnace, when not in use, is closed by two folding-doors, which are elegantly painted to correspond with the folding-doors of the entrance E. The six black spots arranged in a semi-circle, show the site of the iron pillars that support the principal gallery, which is also of the horse-shoe form, as shown by the curved dotted line of that figure, (also exhibited in *Fig.* 2.)

The foregoing plan, although only descriptive of the *ground-floor* of the building, will enable us to explain the appropriation of the rooms and offices of the basement underneath it.

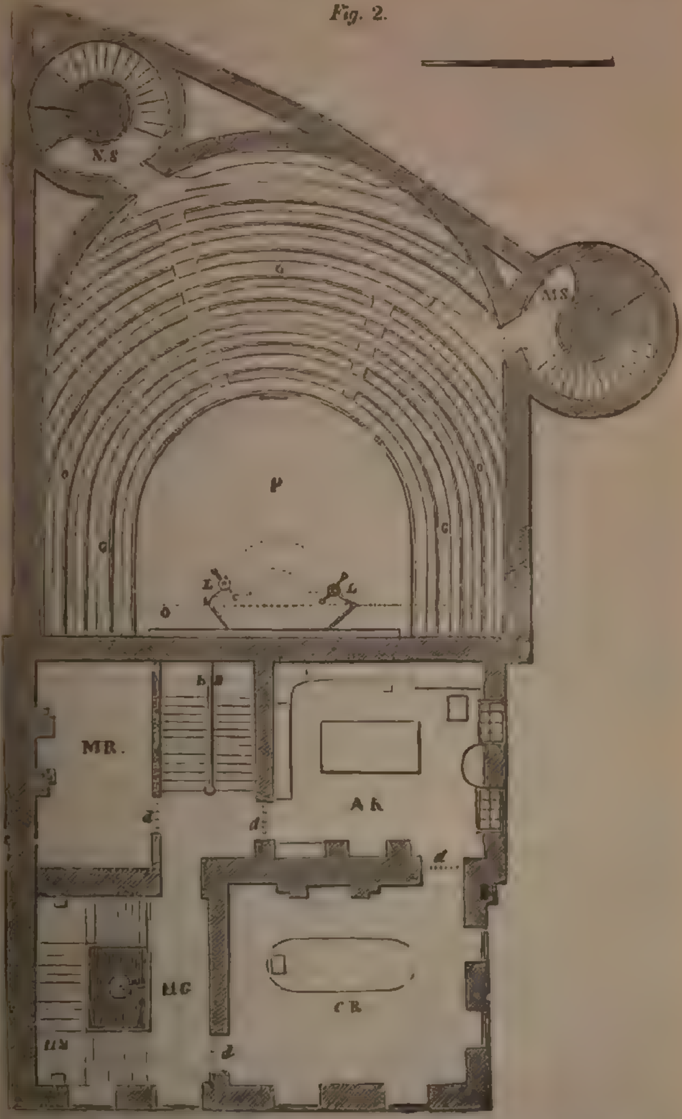
Underneath the hall H, is a kitchen and store-room; underneath the reading-room R R, are the porter's rooms; and underneath the library L, is the laboratory of the same area, containing furnaces, and other requisites for chemical investigations. In this room a class of the members meet weekly for mutual instruction in chemistry, minerology, &c. Adjoining to the laboratory is a small workshop, furnished with an excellent turning-lathe, work-bench, and various tools for the construction and repair of apparatus.

Under the theatre is an extensive class-room, lighted by gass, where practical geometry, perspective, architectural, mechanical, and ornamental drawing, are regularly taught.

The annexed figure (2.) exhibits a plan of the *first-floor of the house*, together with a plan of the gallery of the theatre. H S is the ascending staircase from the hall to the first-floor; H G, the gallery leading therefrom to the several apartments, all the doors or entrances to which are marked with *a d*. C R is the committee-room, furnished with a large table, and other requisites, to accommodate the meetings of the committee of managers, who conduct the affairs of the institution. This room is 19 feet by 21 feet, and one of the side-walls is covered with a glass case, furnished with a splendid collection of minerals. A R is the apparatus-room, or museum, furnished with glass cases around it, containing an extensive assortment of mechanical, pneumatical, hydrostatical, optical, and electrical apparatus; besides a great variety of very large diagrams, for the illustration of those subjects; and an assortment of mineral and geological specimens. This room is open for the accommodation of the members every Tuesday evening, from eight till ten o'clock, to afford them opportunities of inspecting the apparatus, conversing together, and explaining to each other the results of their experience and observations. This mutual interchange of information is calculated to be productive of important advantages to the members. A class for mutual instruction in experimental philosophy, also holds a weekly meeting in this room. M R is another room, similarly appropriated to the last mentioned; it contains various models, and large pieces of apparatus, inconvenient for exhibition in the museum, (A R,) and an extensive collection of transparent illustrations of various sciences. B S, the staircase, leading to the upper floors of the house. The room over the committee-room is a class-room, in which writing, drawing, the English and Latin languages, &c., and occasionally stenography, are taught in the different evenings of the week; and the room over the museum is also a class-room, where mathematics and arithmetic are taught. The other rooms in the upper part of the house are the private apartments of the secretary, who resides on the premises. G G G, show the seats in the gallery of the theatre, rising up an inclined plane; the front, or lowest

…, being upon a level with the first-floor of the house, and the highest, or …k row, being about 17 feet above the lowest. N S is the top of the circular …ne staircase leading from the entrance in Northumberland Court; and M S, …at appertaining to the entrance from Middle Row, Holborn. P is the pit, or

Fig. 2.



…ther ground-floor, of the theatre, the plan of which is given in *Fig.* 1. L L …e two jointed branches for gas-lights, each containing three burners, which …n be moved in various positions, to suit the objects to be illuminated. The

dotted lines *o o o*, show the plan of a lofty rectangular gallery, even with the top of the semi-circular gallery G, from which there are two entrances at the extremities, and another in the middle.

THEODOLITE. A mathematical instrument used by land-surveyors, for taking angles, distances, altitudes, &c. This instrument is variously made, and provided with subordinate apparatus, according to the price, or the requirements of the purchaser. We shall describe one of the most generally useful. This consists of two concentric horizontal circles, the inner of which has, at the ends of one of its diameters, two perpendicular columns, on which rests the horizontal axis of a small meridian telescope. The vernier of the inner circle is made fast to an arbitrary division line of the outer one, and both circles are moved, together with the telescope, until the object sought for appears in its field. The outer circle is now fixed, and the inner one is turned round, until the telescope strikes the second object, whose angular distance from the first is to be measured. The inner circle is now fastened to the outer, and by means of a micrometer screw, the thread of the telescope is brought exactly upon the object. The arc which the vernier of the inner circle has described on the outer one measures the angle which the two objects make at the common centre of the two circles.

THEOREM. A proposition which terminates in theory, and which considers the properties of things already made or done. Or, theorem is a speculative proposition, deduced from several definitions compared together.

THEORY. A doctrine which terminates in speculations, without any view to the practice or application of it.

THERMOMETER. An instrument for measuring the temperature of bodies; founded upon the principle of augmentation in volume of fluids, in proportion to their absorption of caloric; and as regards aeriform fluids, the principle is probably very correct: but solids, and still more liquids, expand unequally, by equal increments of heat. Thermometers were invented about the beginning of the seventeenth century; but a knowledge of their author is involved in some obscurity. For the first half century, after their introduction, they were made in a very rude and imperfect manner; but they were at length considerably improved by the Florentine academicians, and received subsequent ameliorations from Mr. Boyle, Dr. Halley, and Sir Isaac Newton, as well as from contemporaneous philosophers on the continent. The changes which the instrument underwent in their hands, (described in the *Oxford Encyclopædia,*) we shall not here insert, as all that had at that time been proposed, were liable to many conveniences, and could not be considered as exact standards for pointing out the various degrees of temperature.

The thermometers which at present are in most general use, are Fahrenheit's, De l'Isle's, Reaumur's, and Celsius's. Fahrenheit's are used in Britain, De l'Isle's in Russia, Reaumur's, and the thermometer centrigade, in France, and Celsius's, the same as the last named, in Sweden. They are all mercurial thermometers.

Fahrenheit's thermometer consists of a slender cylindrical tube, and a small longitudinal bulb. To the side of the tube *a*, is annexed a scale *b*, which Fahrenheit divided into 600 parts, beginning with that of the severe cold which he had observed in Iceland in 1709, or that produced by surrounding the bulb *c* of the thermometer with a mixture of snow or beaten ice, and sal ammoniac, or sea salt. This he apprehended to be the greatest degree of cold; and accordingly he marked it, as the beginning of his scale, with 0; the point at which mercury begins to boil, he conceived to show the greatest degree of heat, and this he made the limit of his scale. The distance between these two points, he divided into 600 equal parts or degrees; and by trials, he found that the mercury stood at thirty-two of these divisions, when water just begins to freeze, or snow or ice just begins to thaw; it was, therefore, called the degree of the freezing point. When the tube was immersed in boiling water, the mercury rose to 212, which, therefore, is the boiling point, and is just 180 degrees above the former, or freezing point. But the present method of making the scale of these thermometers, which is the sort in most common use.

is first to immerge the bulb of the thermometer in ice or snow just beginning to thaw, and mark the place where the mercury stands, with number 32; then immerge it in boiling water, and again mark the place where the mercury stands in the tube; which mark, with the number 212, exceeding the former by 180, dividing therefore the intermediate space into 180 equal parts, will give the scale of the thermometer, and which may afterwards be continued upwards or downwards at pleasure. Other thermometers of a similar construction have been accommodated to common use, having but a portion of the above scale. They have been made of a small size and portable form, and adapted with appendages to particular purposes; and the tube, with its annexed scale, has often been inclosed in another thicker glass tube, also hermetically sealed, to preserve the thermometer from injury.

In 1733, M. De l'Isle, of Petersburgh, constructed a mercurial thermometer, on the principles of Reaumur's spirit thermometer. In his thermometer, the whole bulk of quicksilver, when immerged in boiling water, is conceived to be divided into 100,000 parts; and, from this one fixed point, the various degrees of heat, either above or below it, are marked in these parts on the tube or scale, by the various expansion or contraction of the quicksilver, in all imaginable varieties of heat.

The thermometer at present used in France is called Reaumur's, but it is very different from the one originally invented by Reaumur in 1730, in which spirits of wine was used to indicate the degrees of expansion. The thermometer now in use in France is filled with mercury; and the boiling-water, which is at 80, corresponds with the 212th degree of Fahrenheit. The scale, indeed, commences at the freezing point, as the old one did. The new thermometer ought more properly to be called De Luc's thermometer, for it was first made by De Luc. When De Luc had finished the scale, and completed an account of it, he showed the manuscript to M. De la Condamine. Condamine advised him to change the number 80; remarking, that such was the inattention of physicians, that they would probably confound it with Reaumur's. De Luc's modesty, as well as a predilection for the number 80, founded, as he thought, on philosophical reasons, made him decline following this advice; but he found by experience, that the prediction of Condamine was too well founded. The thermometer of Celsius, which is used in Sweden, has a scale of 100 degrees from the freezing to the boiling-water point.

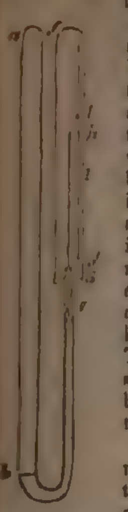
The *thermometer centigrade*, now used in France, has the scale divided in the same way. Many other thermometers have been used besides these, and consequently observations taken by them; but it is unnecessary to describe any of these more minutely, as they are no longer used. Those who wish to read a more particular account of them may consult Dr. Martine's Essays. It must be admitted that disadvantages attend the adoption of the scales of each of the thermometers we have described, but hitherto the sanction of long usage in the countries where they have been introduced, has prevented their being superseded by any other.

A self-registering thermometer has been invented by Mr. Keith, of Ravelstone, which is considered as most ingenious and simple. *a b*, in the annexed figure, is a thin glass tube, about fourteen inches long, and three-fourths of an inch calibre, close or hermetically sealed at top. To the lower end, which is open, there is joined the crooked glass tube *b e*, seven inches long, and four-tenths of an inch calibre, and open at top. The tube *a b* is filled with the strongest spirit of wine, and the tube *b e* with mercury. This is properly a spirit-of-wine thermometer, and the mercury is used merely to support a piece of ivory, or glass, to which is affixed a wire for raising one index, or depressing another, according as the mercury rises or falls. E is a small conical piece of ivory or glass, of such a weight as to float on the surface of the mercury. To the float is joined a wire, called the float-wire, which reaches upwards to H,

Correspondence of the Thermometers of Fahrenheit *and* Reaumur, *and that of* Celsius, *or the Centigrade Thermometer of the modern French Chemists.*

Fahr.	Reaum.	Celsius.	Fahr.	Reaum.	Celsius.	Fahr.	Reaum.	Celsius.	Fahr.	Reaum.	Celsius.	Fahr.	Reaum.	Celsius.
212	80.	100.	161	57.3	71.6	110	34.6	43.3	59	12.	15.	8	10.6	13.3
211	79.5	99.4	160	56.8	71.1	109	34.2	42.7	58	11.5	14.4	7	11.1	13.8
210	79.1	98.8	159	56.4	70.5	108	33.7	42.2	57	11.1	13.8	6	11.5	14.4
209	78.6	98.3	158	56.	70.	107	33.3	41.6	56	10.6	13.3	5	12.	15.
208	78.2	97.7	157	55.5	69.4	106	32.8	41.1	55	10.2	12.7	4	12.4	15.5
207	77.7	97.2	156	55.1	68.8	105	32.4	40.5	54	9.7	12.2	3	12.8	16.1
206	77.3	96.6	155	54.6	68.3	104	32.	40.	53	9.3	11.6	2	13.3	16.6
205	76.8	96.1	154	54.2	67.7	103	31.5	39.4	52	8.8	11.1	1	13.7	17.2
204	76.4	96.5	153	53.7	67.2	102	31.1	38.8	51	8.4	10.5	0	14.2	17.7
203	76.	95.	152	53.3	66.6	101	30.6	38.3	50	8.	10.	1	14.6	18.2
202	75.5	94.4	151	52.8	66.1	100	30.2	37.7	49	7.5	9.4	2	15.1	18.8
201	75.1	93.8	150	52.4	65.5	99	29.7	37.2	48	7.1	8.8	3	15.5	19.4
200	74.6	93.3	149	52.	65.	98	29.3	36.6	47	6.6	8.3	4	16.	20.
199	74.2	92.7	148	51.5	64.4	97	28.8	36.1	46	6.2	7.7	5	16.4	20.5
198	73.7	92.2	147	51.1	63.8	96	28.4	35.5	45	5.7	7.2	6	16.8	21.1
197	73.3	91.6	146	50.6	63.3	95	28.	35.	44	5.3	6.6	7	17.3	21.6
196	72.8	91.1	145	50.2	62.7	94	27.5	34.4	43	4.8	6.1	8	17.7	22.2
195	72.4	90.5	144	49.7	62.2	93	27.1	33.8	42	4.4	5.5	9	18.2	22.7
194	72.	90.	143	49.3	61.6	92	26.6	33.3	41	4.	5.	10	18.6	23.3
193	71.5	89.4	142	48.8	61.1	91	26.2	32.7	40	3.5	4.4	11	19.1	23.8
192	71.1	88.8	141	48.4	60.5	90	25.7	32.2	39	3.1	3.8	12	19.5	24.4
191	70.6	88.3	140	48.	60.	89	25.3	31.6	38	2.6	3.3	13	20.	25.
190	70.2	87.7	139	47.5	59.4	88	24.8	31.1	37	2.2	2.7	14	20.4	25.5
189	69.7	87.2	138	47.1	58.8	87	24.4	30.5	36	1.7	2.2	15	20.8	26.1
188	69.3	86.6	137	46.6	58.3	86	24.	30.	35	1.3	1.6	16	21.3	26.6
187	68.8	86.1	136	46.2	57.7	85	23.5	29.4	34	0.8	1.1	17	21.7	27.2
186	68.4	85.5	135	45.7	57.2	84	23.1	28.8	33	0.4	0.5	18	22.2	27.7
185	68.	85.	134	45.3	56.6	83	22.6	28.3	32	0.	0.	19	22.6	28.3
184	67.5	84.4	133	44.9	56.1	82	22.2	27.7	31	0.4	0.5	20	23.1	28.8
183	67.1	83.8	132	44.4	55.5	81	21.7	27.2	30	0.8	1.1	21	23.5	29.4
182	66.6	83.3	131	44.	55.	80	21.3	26.6	29	1.3	1.6	22	24.	30.
181	66.2	82.7	130	43.5	54.4	79	20.8	26.1	28	1.7	2.2	23	24.4	30.5
180	65.7	82.2	129	43.1	53.8	78	20.4	25.5	27	2.2	2.7	24	24.8	31.1
179	65.3	81.6	128	42.6	53.3	77	20.	25.	26	2.6	3.3	25	25.3	31.6
178	64.8	81.1	127	42.2	52.7	76	19.5	24.4	25	3.1	3.8	26	25.7	32.2
177	64.4	80.5	126	41.7	52.2	75	19.1	23.8	24	3.5	4.4	27	26.2	32.7
176	64.	80.	125	41.3	51.6	74	18.6	23.3	23	4.	5.	28	26.6	33.3
175	63.5	79.4	124	40.8	51.1	73	18.2	22.7	22	4.4	5.5	29	27.1	33.8
174	63.1	78.8	123	40.4	50.5	72	17.7	22.2	21	4.8	6.1	30	27.5	34.4
173	62.6	78.3	122	40.	50.	71	17.3	21.6	20	5.3	6.6	31	28.	35.
172	62.2	77.7	121	39.5	49.4	70	16.8	21.1	19	5.7	7.2	32	28.4	35.5
171	61.7	77.2	120	39.1	48.8	69	16.4	20.5	18	6.2	7.7	33	28.8	36.1
170	61.3	76.6	119	38.6	48.3	68	16.	20.	17	6.6	8.3	34	29.5	36.6
169	60.8	76.1	118	38.2	47.7	67	15.5	19.4	16	7.1	8.8	35	29.7	37.2
168	60.4	75.5	117	37.7	47.2	66	15.1	18.8	15	7.5	9.4	36	30.2	37.7
167	60.	75.	116	37.3	46.6	65	14.6	18.3	14	8.	10.	37	30.6	38.3
166	59.5	74.4	115	36.8	46.1	64	14.2	17.7	13	8.4	10.5	38	31.1	38.8
165	59.1	73.8	114	36.4	45.5	63	13.7	17.2	12	8.8	11.1	39	31.5	39.4
164	58.6	73.3	113	36.	45.	62	13.3	16.6	11	9.3	11.6	40	32.	40.
163	58.2	72.7	112	35.5	44.4	61	12.8	16.1	10	9.7	12.2			
162	57.7	72.2	111	35.1	43.8	60	12.4	15.5	9	10.2	12.7			

where it terminates in a knee bent at right angles. The float-wire, by means of an eye at *b*, moves easily along the small harpsichord wire *g h*. *l l* are two indexes made of thin black oiled silk, which slide upwards or downwards with a force of not more than two grains. The one placed above the knee points out the greatest rise, and the one placed below it points out the greatest fall, of the thermometer. When the instrument is to be prepared for an observation, both indexes are to be brought close to the knee *h*. It is evident, that when the mercury rises, the float and float-wire, which can be moved with the smallest force, will be pushed upwards till the mercury becomes stationary. As the knee of the float-wire moves upwards, it will carry along with it the upper index *l*. When the mercury again subsides, it leaves the index at the highest point at which it was raised, for it will not descend by its own weight: as the mercury falls, the float-wire does the same; it therefore brings along with it the lower index *l*, and continues to depress it till it again becomes stationary, or ascends in the tube; in which case it leaves the lower index behind it, as it had formerly left the upper. The scale to which the indexes point is placed parallel to the slender harpsichord wire. That the scale and indexes may not be injured by the wind and rain, a cylindrical glass cover, close at top, and made so as exactly to fit the part *g f*, is placed over it.



As a knowledge of the correspondence between the thermometers of Fahrenheit, Reaumur, and Celsius, are indispensable to the comprehension of the scientific labours of the French and German philosophers and authors, whether in the original languages, or the English translations, we have inserted a table in which the degree of any given temperature under 212° of Fahrenheit is expressed by those of Reaumur and Celsius: we omit De Lisle's, its use being confined to Russia. As, however, higher degrees of temperature may be required than those given in the table, the following rules are given for changing the degrees of any one of the scales into equivalent degrees of another; viz. each degree of Fahrenheit is equal to four-ninths of one of Reaumur; as Reaumur, however, reckons his degrees from the freezing point, and Fahrenheit 32° below this point, we must, when the number of Fahrenheit's degrees to be reduced indicate a temperature above the freezing-point, first deduct 32, then multiply the remainder by 4, and divide the product by 9. The quotient is the corresponding number of degrees on Reaumur's scale. If the temperature indicated was less than the freezing point, we must also be careful to take the actual number of degrees, reckoning from the freezing point. Thus 4 degrees above Fahrenheit's zero is 28 below his freezing point; and this is the number to be reduced to Reaumur's scale.

Each degree of Reaumur is equal to $2\frac{1}{4}$ of one of Fahrenheit. Multiply the given number of degrees of Reaumur by 9, and divide the product by 4. If the degrees of Reaumur were minus, the quotient must be deducted from 32, and the remainder will be the equivalent degrees of Fahrenheit. If the given degrees were not minus, the quotient must be added to 32 degrees, and the sum will be the equivalent sought.

Each degree of Fahrenheit is equal to $\frac{5}{9}$ of one of the centigrade. Proceed as in the case of Fahrenheit and Reaumur, multiplying, however, by 5, and dividing by 9.

Each degree of Reaumur is equal to $1\frac{1}{4}$ of the centigrade. Multiply the given number of degrees by 5, divide the product by 4, and the quotient will be the equivalent number of degrees on the centigrade scale.

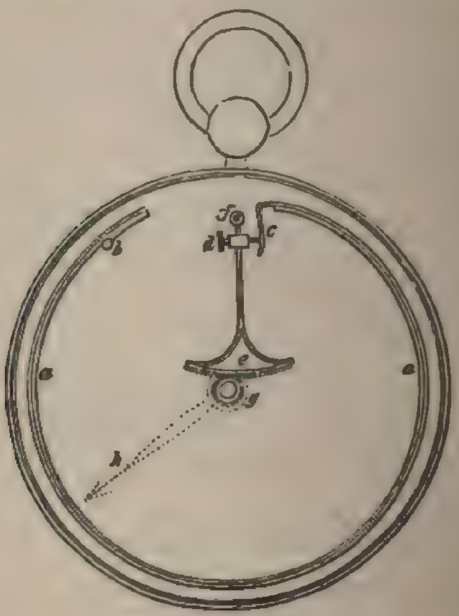
Each degree of the centigrade scale is equal to four-fifths of Reaumur. Multiply the given number of degrees of the centigrade by 4, and divide the product by 5; the quotient will be the equivalent number of degrees on Reaumur's scale.

The different degrees of expansibility of dissimilar metals by the same increase of temperature, is well known, and has been usefully employed to produce compensation in the regulators of time-keepers; and recently a very portable and convenient thermometer has been made on the same principle.

The one from which we made the diagram on the next page, is contained in a common-sized pocket-watch, and indicates the temperature from 30° below zero to 80° Reaumur, equal to the extent from zero, to 212° on Fahrenheit's scale.

It consists of a slip of steel on a slip of brass attached together, and bent with the brass inwards, into a circular form *a a*, and fixed to the frame of the watch at *b*, immediately behind the dial. One end of this circular piece is bent inwards at *c*, and acts upon a lever, *e f*, of the third order. The lever moves upon a pivot at *f*, is furnished with an adjusting screw *d*, and a toothed segment *e*. The teeth of this segment act upon the teeth of a small pinion *g*, to the projecting pivot of which an index *h* is attached.

The action of this little instrument is obvious; for as the interior portion of the compound circular piece is of brass, which is more expansible than the exterior, which is of steel, an increase of heat will cause the ring to open; but in opening it acts upon the lever, and by that means turns the index, which points out by the graduated circle on the face of the watch the quantity of increase. On the contrary, when a decrease of heat takes place, the ring will have a tendency to close, and the lever being kept up to it by a small spring on the opposite side, acts upon the index, and points the quantity of decrease in the temperature. This thermometer indicates a change of temperature much quicker than the common mercurial thermometer, owing to the metals being better conductors of caloric, than wood or glass, the substances of which they are usually manufactured.



A *Thermometer of Contact* has lately been invented by M. Fourrier. "It is well known," says M. Fourrier, "that on touching different substances maintained at the same temperature, the same calorific impression is not received in consequence of the different conductibility of those bodies. It is even sufficient to cover those bodies with a thin sheet of paper, sensibly to change the effect of the contact. If, then, on a support kept at a constant

, for example, at that of melting ice, thin sheets of different are successively applied, the simple contact of the naked hand will as a great number of them according to their order of conductibility; hod is by no means accurate, and is liable to other inconveniences. 's instrument may be considered as an improved hand, and minutely the facts to which the application of the hand only makes an ion. It is extremely simple; it consists of a cone of very thin iron, mercury, and terminated at its circular base by a skin of moderate A thermometer is placed in the mercury; it is this skin which is thin sheet applied to the support. The contact is very intimate, in of its flexibility; and the thermometer indicates the variations of . By this instrument many curious facts have already been For instance, it has been shown, that the order in which thin ferent substances are placed one upon another, influences the quantity ch passes through them under the same external circumstances. terposition of a sheet of leather facilitates the transmission of heat cloth, and it obstructs it from cloth to marble.

rmometers hitherto described are very limited in their extent; they out to us the lowest degrees of heat which are commonly observed d climates, but they by no means reach to those degrees of heat ery familiar to us. The mercurial thermometer extends no farther of Fahrenheit's scale, the heat of boiling mercury; but we are sure of solid bodies, when heated to ignition, or till they emit light, far heat of boiling mercury. In order to remedy this defect, Sir Isaac mpted, by an ingenious experiment, to extend the scale to any degree His plan, however, was not found convenient for practical purposes. the idea suggested by Newton, the late Mr. Wedgwood invented le thermometer, which marks with much precision the different nition from a dull red heat visible in the dark, to the heat of an

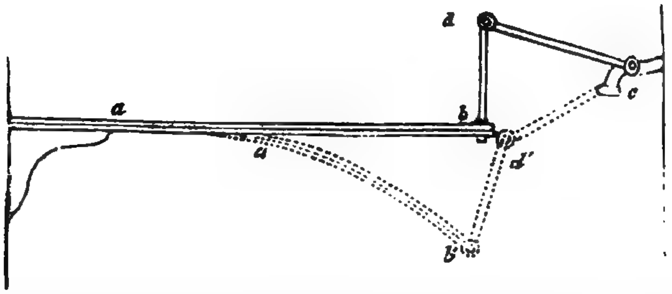
the annexed figure, is a smooth flat plate; on which are fixed flat pieces, a quarter of an inch thick, lying flat upon the plate, s that are towards one another made perfectly true, a little further one end, than at the other end; thus they include between converging canal, which is divided on one side into a number of small equal parts, and which may be considered as performing the offices both of the tube and scale of the common thermometer. It is obvious, that if a body, so adjusted as to fit exactly at the wider end of this canal, be afterwards diminished in its bulk by fire, as the thermometer pieces are, it will then pass further into the canal, and more and more so according as the diminution is greater; and conversely, that if a body so adjusted as to pass on to the narrow end, be afterwards expanded by fire, as is the case with metals, and applied in that expanded state to the scale, it will not pass so far; and that the divisions on the side will be the measures of the expansions of the one, as of the contractions of the other, reckoning in both cases from that point to which the body was adjusted at first. *i* is the body whose alteration of bulk is thus to be measured. This is to be gently pushed or slid along towards the narrow end till it is stopped by the converging sides of the canal. Mr. Walker, to whom we have already alluded, suggests the idea of a metallic thermometer which shall embrace the medium between the highest point of the mercurial thermometer, which terminates at 600 degrees, and the lowest of Wedgwood's, just described, which commences at 1077 degrees of Fahren-

llic composition is formed, not liable to alteration in its quality repeated exposure to heat, the melting point of which is at a little rees of Fahrenheit, and its boiling point at 1200 degrees. A case form the glass case for the ordinary thermometer, but somewhat

larger, contains the metallic composition, and the scale consists in a slender graduated rod, equal in height at the commencement of the scale; that is, when the metallic composition is just liquid to the top of the tube, the graduated rod terminating at the bottom in a thin, circular, flat plate, which rests or floats as it were upon the liquid metal; and in proportion as the latter expands and rises in the tube by heat, the graduated rod is buoyed up, or raised above the top of the tube, passing through a perforated cover to the maximum, or boiling point. The thermometer case and graduated rod are formed of pipe-makers' clay, previously prepared by having been exposed to a sufficient degree of heat. The scale of this new thermometer is an exact continuation of the scale in the mercurial thermometers; the lower degrees of the former corresponding with, or indicating like, temperatures with the upper degrees of the mercurial thermometer.

"The same principle," says Mr. Walker, "I might observe, admits of being extended, for the purpose of ascertaining the variation in temperature, up to the most intense heat, perhaps, that can be required. It is unnecessary to state here, that the influence of the incumbent atmosphere upon the surface of the liquid metal within the open tube is too inconsiderable, even at the commencement of the scale, to deserve notice, and at a higher temperature diminishes to nothing; especially if the whole of the liquid contained in the thermometer, as ought to be the case in every thermometer, be completely immersed, or subjected to the temperature, the degree of which it is intended to indicate. A method similar to the above, I should think, might be applicable to the purpose of showing, in a ready way, the degree of expansion in metals by heat; but the elongation of a cylinder of any metal, by increase of temperature, is much too small to admit of its being a convenient measure of temperature. I should not despair, however, availing myself of every advantage, viz., increasing the length of a metallic wire, by giving it a spiral form, in order to comprise a considerable length in small compass, with the application of the lever-index, and a good magnifier, upon constructing a thermometer upon this principle, so as to render the scale apparent even to single degrees; using silver for the lower temperatures, and platina for the higher, or employing iron wire, only up to its ultimate point of expansion in a solid state.

THERMOSTAT. The name given to an instrument invented and recently patented by Dr. Ure, for regulating temperature in vaporization, distillation, and other processes, in which the agency of heat is required. It is effected by increasing or diminishing the size of the apertures through which the calorific medium is transmitted. The nature of the contrivance, and its mode of action, will be understood by reference to the annexed diagram.



a b, represent a compound bar, composed of two flat pieces of metal, possessing different powers of expansibility by the same increase of temperature, such as iron and zinc, firmly rivitted together. Now, suppose the most expansible metal, the zinc, placed on the upper side, the compound bar will bend downwards to the position represented at *a' b'*; and by diminution of the temperature below that at which the metals were rivetted together, a flexure in the con-

ry direction would take place; and thus a motion is obtained from any change temperature, which may be made, through the medium of levers, available in cking the cause of change, by altering the size of the opening through which change was effected. Let c represent a stop-cock, through which steam, hot ter, or other fluid enters, to communicate heat to the vessel containing the rmostat $a\ b$, and let $c\ d$ be a lever or handle, by which the cock is turned, ned to the compound bar, by the connecting-rod $d\ b$; also, let the plug or cock be so adjusted, that it shall be partially open when the lever is in the ition represented by $c\ d$; and less open when in the position represented by ; then it is evident, that any increase of temperature, beyond that to which instrument may have been adjusted, would, by causing the instrument to d downwards, immediately diminish the passage, and consequently the sup-y of steam, hot water, or whatever fluid may be used for communicating heat. hile, on the contrary, a diminution in the temperature would cause the bar to nd upwards, and thus increase the passage for the admission of a greater quan-y of the heating vapour or fluid.

The patentee gives a variety of examples, of the application of his thermo- for regulating the admission of heating fluids, as well as for regulating ventilation of rooms, public buildings, &c., some of them displaying con-lerable ingenuity; but they all depend upon the principle above explained, therefore we have not deemed it necessary to describe them.

THIMBLE. A metallic case, worn by tailors and sempstresses upon the ger, for the purpose of pressing needles through the stuff in sewing. An in-ment, answering the same purpose, is worn by sailors and sail-makers in the lms of their hands by straps which fasten it thereto; they are technically lled palms, and are small circular plates of cast iron, indented on the surface. mble is the name also given to circular rings of iron, hollow on the outside, a rope which envelopes it to be securely imbedded therein; a metallic eye is formed, for passing another rope through, or hanging on to it by a hook, a kle block, &c.

THRESHING-MACHINE. An apparatus for separating the grain from the aw Machines for this purpose were contrived as far back as 1732; these were siderably improved by Mr. Andrew Meikle, in 1785, who took a patent for his provements, which are described in the "Repertory of Arts." Since that time y have undergone various ameliorations; and the construction of those which mostly employed at the farm-houses, may be briefly described as consisting three rotatative drums or cylinders; around the first which comes into operation a series of arms, or beaters, which are made to revolve, and thereby strike corn (supplied underneath them by feeding rollers,) with great rapidity. nce the thereshed corn is carried on by the motion of the feed rollers, to two cessive straw shakers, which consist (as before mentioned) of a rotative frame, med with numerous spikes, that lift up and shake the straw, so as to force from ongst it the grain, and allow it to fall through a grated floor, into a large hop- beneath. From this hopper the corn is conducted to another receptacle, and its passage winnowed by fanners driven with great velocity, that separate the ff, by blowing it away into another receptacle. Of course the power by ich such machines are driven depends upon local circumstances; but in eral a horse-wheel is employed, worked by the united force of three horses; horse-wheel is mounted with a large horizontal wheel which drives a pinion the main shaft of the threshing-machine; and the main shaft, by suitable , gives motion at the requisite velocities to the parts we have described.

TIDE. A regular periodical current of water, setting alternately in a flux reflux, and generally considered to be produced by the influence of the on The sagacious Locke, in describing the theory of the tides, observes, hat motion of the water called the tides, is a rising and falling of the sea; cause of this is the attraction of the moon, whereby the part of the water the great ocean, which is nearest the moon, being most strongly attracted, is higher than the rest; and these two opposite elevations of the surface of in the great ocean, following the motion of the moon from east to , and striking against the large coasts of the continents, from thence ound back again, and so make floods and ebbs in narrows, seas, and rivers.

TIDE-MILLS. Are mills or any kind of machinery moved by the ebbing and flowing of the tide. Mills of this kind are not very common, on account of the great expense of their construction; but in situations where the tide rises to a considerable height, and where the fuel required for a steam-engine is high, and the first cost can be met, tide-mills may be very advantageously constructed.

The origin of tide-mills in this country does not appear to be recorded; but the able Belidor ascribes the invention to a master-carpenter, at Dunkirk, of the name of Perse. Mills to be worked by the rising or falling of the tide, admit of great variety in the essential parts of their construction; but this variety, Dr. Gregory observes, may be reduced to four general heads, according to the manner of action of the water-wheel. 1st, the water-wheel may turn one way when the tide rises, and the contrary when it falls. 2d, the water-wheel may be made to turn always in one direction. 3d, the water-wheel may rise and fall, as the tide ebbs and flows. 4th, the axle of the water-wheel may be so fixed as that it shall neither rise nor fall, though the rotary motion shall be given to the wheel, while at one time it is only partly, at another completely immersed in the fluid.

Some very ingenious suggestions for the construction of a tide-mill appeared some time since in a scientific journal, in which the arrangements differ in some essential respects from those apparently contemplated in Dr. Gregory's classification. We shall insert the description in the author's own words.

Fig. 1.

In this plan, "the water is compelled to flow in and out of a basin, in such a manner, that the greatest force shall be obtained from its current, and the annexed diagrams are introduced to illustrate the following explanation."

Fig. 1 represents a perpendicular projection of the principal parts on a plane, supposed to be drawn longitudinally and vertically through the centre of the work. *h v* show the respective heights of the water, on each side of the flood-gate *s*; the flushes, *i* on *b's* side, and *k* on *c's*, are supposed to be open, and

o the nomination of the parts, the water is flowing from the basin
.
presents a perpendicular projection of the principal parts on a plane,
o be drawn latitudinally and vertically through the centre of the

Fig. 2

shows the level of the water when flowing from the represented side; n of the flushes under these circumstances are shown, *i* being open, ed; *v* shows the level; *vice versa*, the position of the flushes in this een, *i* being closed, and *k* open. An objection may arise from the of the quantity of water at the spring and neap tides. To counteract lush *l* is introduced into the flood-gate *s*, which may be opened and ording as there is a redundancy or deficiency of water: this may ffected by centrifugal balls, or by the attention of the individual who of the works. It should be entirely opened when the mill is not

h this plan is more particularly adapted for harbours and the tideway yet there are few parts of the coast on which such a mill might not be d. If it be on a sandy beach, a large wooden tunnel should be laid the lowest tide level, in order to introduce water upon the flood-gate. had better be constructed of wood, as then the sides of it may be hich is of great advantage, to produce a less variable current; but it cavated, and lined with clay, which should be covered over with n order to prevent the clay from being washed off. If it be on a rocky is before exposed to a surf, there should be a small tunnel excavated, by dotted lines at *t*.) The basin in this case is easily formed; I that an excavation of the capacity of one of our first-rate ships, and feet deep, would contain water enough to two pair of stones for a

a floating mill, of which the form of a ground plan is as *Fig* 2. It

[illegible]: 1st, because the building may be more easily [illegible] to bear the pressure on the [illegible] to give a proper direction [illegible] basin; *c* the sea or harbour; [illegible] attached to the mill, and [illegible] with the tide; *j*, the water-wheel; [illegible] water on the wheel; *k k* ditto, for [illegible] regulating the influx of water [illegible] the tide; *d*, the channel cut in [illegible] and sunk below low-water mark, [illegible] fall of the tide above, into which are inserted small [illegible] plate placed on the flood-gate, in order to reduce [illegible] vertical beams of timber, supported by pieces *o o*, thrown [illegible] horizontally and diagonally, with respect to the beam itself, [illegible] bearing the horizontal pressure of the building on the [illegible] pressure takes place on each beam alternately, with the rise [illegible] are doors, the upper one may receive the corn or [illegible] mill is at a proper level, and the lower one discharge the [illegible] a convenient situation; leather is placed in the joints, in such a [illegible] prevent the water from getting through between the slide and [illegible] There are two water-wheels, in order that the pressure on the groove [illegible]

[illegible] was erected at East Greenwich, on the right bank of the [illegible] direction of Mr. John Lloyd, an engineer of Westminster, [illegible] will convey an idea: the details are given by Dr. Gregory [illegible], vol. ii.

[illegible] intended to grind corn, and works eight pair of stones. The [illegible] house parallel to the course of the river, measures 40 feet [illegible] as the whole of this may be opened to the river by sluice-[illegible] carried down to the low-water mark in the river, there is a 40 [illegible] to the mill; through the water-way the water presses during [illegible] into a large reservoir, which occupies about four acres of land. [illegible] reservoir is a smaller one, in which water is kept, for the purpose [illegible] occasionally at low water to cleanse the whole works from mud [illegible] which would otherwise, in time, clog the machinery.

[illegible] has its axle in a position parallel to the side of the river, [illegible] to the sluice-gates which admit water from the river; the length [illegible] 20 feet, its diameter 11 feet, and its number of float-boards 32. [illegible] not each run on in one plane from one end of the wheel to the [illegible] whole length of the wheel is divided into four equal portions, and [illegible] float-boards belonging to each of these portions fall gradually [illegible] another, each by one-fourth of the distance, from one board to [illegible] on the circumference of the wheel.

[illegible] is intended to equalize the action of water upon the wheel, [illegible] moving by jerks. The wheel, with its incumbent apparatus, [illegible] the whole of which is raised by the impulse of the flowing [illegible] through the sluice-gates. It is placed in the middle of the [illegible] a passage on each side of about six feet, for the water to [illegible] river, besides that which, in its motion, turns the wheel round [illegible] has risen to the highest, (which at this mill is often 20 feet [illegible] water-mark,) the water is permitted to run back again from the [illegible] river, and by this means it gives a rotary motion to the [illegible] contrary direction to that with which it moved when impelled [illegible]

[illegible] of red earthenware, used for the coverings of buildings, also [illegible] other purposes. They are made of the better kind of brick-[illegible] free from stones and other foreign matter, then moulded [illegible] according to the purposes required, and baked in kilns.

[illegible] bar or lever employed to turn the rudder in floating vessels [illegible] steering.

. The awning or canopy spread over boats, waggons, and other

HAMMER. A large heavy hammer, worked by machinery. See

. According to Mr. Locke, is "the measure of duration." "We acquire ns of time," says Dr. Robison, "by our faculty of memory, in observing ssion of events. Time is conceived by us as unbounded, continuous, eous, unchangeable in the order of its parts, and divisible without end. daries between successive portions of time may be called instants, and ortions of it may be called moments. Time is conceived as a proper made up of, and measured by, its own parts. In our actual measure- employ some event, which we imagine always to require an equal its accomplishment; and this time is employed as a unit of time on, in the same manner as we employ a foot-rule as a unit of exten- s often as this event is accomplished during some observed operation, o we imagine that the time of the operation contains this unit. It is we affirm that the time of a heavy body falling 144 feet is thrice as the time of falling 16 feet; because a pendulum, 39⅛ inches long, makes rations in the first case, and one in the last." "There is an analogy," learned author, "between the affections of space and time, so obvious, most languages the same words are used to express the affections of Hence it is that time may be represented by lines, and measured by mo- uniform motion is the simplest succession of events that can be con- This further analogy also occurs between time and space, namely, n space all things are placed in the order of situation, so in time all ur in the order of succession. (See *Elements of Mechanical Philo- y* John Robison, LL.D., Vol. I.) Like place, time may also be dis- d into absolute and relative. *Absolute time* is time considered in itself, any relation to bodies or their motions. *Relative*, or *apparent time*, is ble measure of any duration by means of motion. Time is also astro- or civil. *Astronomical time* is that of which the computation and depend solely on the motion of the heavenly bodies. *Civil time* is ical time modified, and accommodated to the purposes of civil life.

-KEEPER. An instrument for measuring time. See HOROLOGY.

A metal of a white colour, intermediate between silver and lead. It derably harder than lead; scarcely at all sonorous; very malleable, being of extension, under the hammer, to about a two-thousandth part of an thickness. The ordinary tinfoil is about a one-thousandth part of an . Tin has a slight unpleasant taste, and emits a peculiar smell when Specific gravity, 7.291. It is very flexible, producing a remarkable crack when bended, the loudness of which is a common, though not very ac- t of its purity. Tin melts at 442° Fahr.; when fresh cast, or fresh It is very brilliant, but it gradually loses its lustre by exposure to the air, ires a greyish-white tint, which does not sensibly change. Like lead, ated nearly to fusion, it is brittle, and may be easily broken up by a when it exhibits a grained or fibrous texture. It may also be reduced by agitation, at the period of its transition from the solid to the fluid

are several kinds or qualities of tin. The Cornish block tin is usually s of about three cwt. each; which are, however, run into smaller masses, 40 lbs. each, for the convenience of trade. The common block tin is ated with a minute quantity of other metals, generally copper, to the f about a thousandth part. "Refined block-tin" is in blocks of tin to long narrow sticks, of a few ounces each. The "grain tin" is the the several English kinds, being obtained from the pure oxide of tin am-works of Cornwall. It is first cast into blocks of about 120 lbs. each, rwards melted, so as to separate it into fragments resembling rocks; produced by letting the metal fall, when barely fluid, from a great The tin imported from the East Indies, particularly Malacca, is es- ery pure, and considered the best for organ pipes, and some other uses.

The tin ore of Cornwall, obtained from the mines, is stamped to reduce it into fragments, then washed, to separate the earthy matter, and afterwards roasted in a reverberating furnace; which process is repeated until the assay shows it to contain at least half of its weight of metal, when it is sold to the smelters. In this state it is mixed with culm and slaked lime, well moistened, and then smelted in a reverberating furnace, capable of reducing about 7 cwt. at a time. A given weight of tin, produced from Cornish ore, consumes about double its weight of coal in the operations of roasting and smelting. Between three and four thousand tons of tin are produced annually from the mines of Cornwall. Chaptal says, that if tin be kept in fusion in a lined crucible, and the surface be covered with a quantity of charcoal, to prevent its calcination, the metal becomes whiter, more sonorous, and harder, provided the fire be kept up for eight or ten hours.

Mercury dissolves tin with great facility, and in all proportions. To make this combination, heated mercury is poured on melted tin; the consistence of the amalgam differs according to the relative proportions of the two metals.

Nickel, united to tin, forms a white and brilliant mass. Half a part of tin, melted with two parts of cobalt, and the same quantity of muriate of soda, furnished Beaume with an alloy in small close grains of a light violet colour. Equal parts of tin and bismuth form a brittle alloy, of a medium colour between the two metals, and the fracture of which presents cubical facets.

Zinc unites perfectly with tin, and produces a hard metal, of a close-grained fracture; its ductility increases with the proportion of tin.

Antimony and tin form a white and brilliant alloy, which is distinguished from other alloys of tin by its possessing a less specific gravity than either of the two metals by which it is formed.

In combining arsenic with tin, precautions must be taken to prevent the arsenic from escaping by volatilization. Three parts of tin may be put into a retort, with one-eighth part of arsenic in powder; fit on a receiver, and make the retort red hot; very little arsenic rises, and a metallic lump is found at the bottom, containing about one-fifteenth part of arsenic; it crystallizes in large facets, is very brittle, and hard to melt.

If tin be kept in fusion with access of air, its surface is speedily covered with a greyish pellicle, which is renewed as fast as it is removed. If this grey oxide be pulverized and sifted, to separate the uncalcined tin, and calcined again for several hours, under a muffle, it becomes the yellow oxide of tin, called among artizans *putty of tin*, and extensively used in polishing of glass, steel, and other hard bodies.

A white oxide of tin is used in forming the opaque kind of glass called enamel. This composition is made by calcining 100 parts of lead and 30 parts of tin, in a furnace, and then fluxing these oxides with 100 parts of sand, and 20 of potass. This enamel is white, and is coloured with metallic oxides.

All the mineral acids dissolve tin, and it may be precipitated from its solutions by potass; but an excess of potass will re-dissolve the metal. Nitro-muriate of gold is a test of tin in solution, with which it forms a fine purple precipitate.

The sulphuric acid dissolves tin, whether concentrated or diluted with water; part of the acid is decomposed, and flies off in the form of sulphurous acid gas. Heat accelerates the effect of the acid. Tin, dissolved in the sulphuric acid, is very caustic.

The solution of tin in the nitric acid is performed with astonishing rapidity, and the metal is precipitated almost instantly in the form of a white oxide. If this acid be loaded with all the tin it is capable of calcining, and the oxide be washed with a considerable quantity of distilled water, a salt may be obtained by evaporation, which detonates alone in a crucible well heated, and burns with a white and thick flame, like that of phosphorus. The nitric acid holds but a very small quantity of tin in solution, and when evaporated for the purpose of obtaining crystals, the dissolved portion quickly precipitates, and the acid remains nearly in a state of purity. Nitric acid, much diluted, holds rather more tin in solution, but lets it fall by standing, or by the application of heat.

The muriatic acid dissolves tin, whether cold or hot, diluted or concentrated. If fuming, and assisted by a gentle heat, the addition of the tin instantly causes it to lose its colour and property of emitting fumes, and a slight effervescence takes place. The acid dissolves more than half its weight of tin; the solution is yellowish, of a fetid smell, and affords no precipitate of oxide, like the sulphuric and nitric acids.

The oxy-muriatic acid dissolves tin very readily, and without effervescence, because the metal quickly absorbs the superabundant oxygen from the acid, and requires no decomposition of the water to effect its oxidation.

Nitro-muriatic acid, made with two parts of nitric acid, and one of muriatic acid, dissolves tin with effervescence. It is the solution of tin in this acid which the dyers employ to heighten the colour of their scarlet dyes. It is prepared by adding small portions at a time, of tin, to the common aquafortis of commerce: when the appearance of oxide is observed at the bottom of the jar, muriate of soda is added, by which its solution is effected. If the colour imparted by this solution is not bright, a little nitrate of potass is added to it.

The acetous, and most other vegetable acids, have some action upon tin, particularly when aided by a gentle heat; but the solutions thus obtained are not used in the arts. Tin decomposes the corrosive muriate of mercury. It is for this purpose amalgamated with a small portion of mercury and this amalgam, being first triturated in a mortar with the corrosive muriate, the mixture is then distilled by a gentle heat. A colourless liquor first passes over, and is followed by a thick white vapour, which issues with a kind of explosion, and covers the internal surface of the receiver with a very thin white crust. The vapour becomes condensed into a transparent liquor, which continually emits a thick, white, and very abundant fume. It was formerly called the *fuming liquor of Libavius*, and is the combination of the muriatic acid and tin.

Tin has a strong affinity for sulphur; the sulphuret of tin may be formed by fusing the two substances together: it is brittle, heavier than tin, and not fusible. It has a blueish colour, a lamellated texture, and is capable of crystallizing.

The white oxide of tin combines with sulphur, and forms a compound called *aurum musivum*, or *mosaic gold*, which is much used for giving to plaster-of-Paris the resemblance of bronze, and improving the appearance of bronze itself. It is also occasionally used to increase the effects of electrical machines. See Aurum Musivum.

Tin possesses the property in a remarkable degree of promoting the fusibility of other metals, with which it is mixed. Two parts of lead, and one of tin, which forms the best plumber's solder, melt at a temperature of little more than 300° Fahr.; although the melting point of tin alone is 440°, and that of lead 612°. One part of tin, and two of lead, which forms the inferior plumber's solder, melt at a lower temperature than the first-mentioned proportions, notwithstanding the increased quantity of the less fusible metal. Eight parts of bismuth, (which melts *per se* at 480°,) five of lead, and three of tin, fuse at a heat below that of boiling water. It is this alloy of which tea-spoons are sometimes made, to surprise those who are ignorant of their nature, by their melting in a cup of hot tea.

The uses of tin are so very numerous, and so well known, as not to need detailing. We shall advert to only a few; viz. the fabrication of boilers and kettles for dyers' use; the worms of stills; the drawing of pipes, (erroneously called *pewter*) for gas conduits, for beer, wine, vinegar, and other acetous liquids, which have no action upon pure tin: if the tin were alloyed, it could not be drawn into sound pipes. Tin forms the principal ingredient in pewter of all qualities, and enters largely into the greater part of the white alloys in such extensive use. Immense quantities of tin are used in the fabrication of *tinned* iron plates, improperly called tin-plates. We may also here notice a new and most important application of this pure metal, (under a patent granted to Mr. John Warner, jun. founder, &c., of Cripplegate, London,) which is that of giving a perfect and beautiful coat of tin to lead pipes, which thus possess the valuable qualities of both metals; viz. the cheapness and flexibility of lead, and the purity and indestructibility of tin.

TINNING. The art of covering any metal with a thin coating of tin. Copper and iron are the metals most commonly tinned. The use of tinning these metals is to prevent them from being corroded by rust, as tin is not so easily acted upon by the air or water, as iron and copper are. What are commonly called tin-plates, or sheets, so much used for utensils of various kinds, are, in fact, iron plates coated with tin. The principal circumstance in the art of tinning is, to have the surfaces of the metal to be tinned perfectly clean and free from rust, and also that the melted tin may be perfectly metallic, and not covered with any ashes or calx of tin. When iron plates are to be tinned, they are first scoured, and then put into what is called a pickle, which is sulphuric acid diluted with water; this dissolves the rust or oxide that was left after scouring, and renders the surface perfectly clean. They are then again washed and scoured. They are now dipped in a vessel full of melted tin, the surface of which is covered with fat or oil, to defend it from the action of the air. By this means, the iron coming into contact with the melted tin in a perfectly metallic state, it comes out completely coated. When a small quantity of iron only is to be tinned, it is heated, and the tin rubbed on with a piece of cloth, or some tow, having first sprinkled the iron with some powdered resin, the use of which is to reduce the tin that may be oxidated. Any inflammable substance, as oil for instance, will have in some degree the same effect, which is owing to their attraction for oxygen. Sheets of copper may be tinned in the same manner as iron. Copper boilers, saucepans, and other kitchen utensils, are tinned after they are made. They are first scoured, then made hot, and the tin rubbed on as before with resin. Nothing ought to be used for this purpose but pure grain tin; but lead is frequently mixed with the tin, both to adulterate its quality, and make it lie on more easily; but it is a very pernicious practice, and ought to be severely reprobated.

TITANIUM. A new metal discovered by the Rev. Mr. Gregor, in the beginning of the present century, in Cornwall. Klaproth subsequently found it in the red-shorl of Hungary, and gave it the name of titanium. Lampadius was the first who completely reduced it, which he effected by charcoal only. The metal was of a dark copper colour, with much brilliancy, brittle, and in small scales considerably elastic. It tarnishes in the air, and is easily oxidized by heat: it then acquires a purple tint. It detonates with nitre, and is infusible. All the mineral acids act upon it with great energy. According to Vauquelin, it is volatilized by intense heat.

TOBACCO. The dried leaves of a foreign poisonous plant, most extensively cultivated in many parts of the world, to furnish a species of aliment to the depraved tastes of a large portion of the human race.

Tobacco is a potent narcotic, and also a strong stimulus, and in small doses proves violently emetic and purgative. The oil is remarkable for its extreme malignancy, and when applied to a wound, is said, by Redi, to be as fatal as the poison of a viper. The decoction, smoke, and powder are used in agriculture to destroy insects.

Tobacco being cultivated for the leaves, it is an object to render these as large and also as numerous as possible, and therefore the most fertile soil is preferred. It is very sensible to frost. The plants are raised on beds, early in spring, and when they have acquired four leaves, they are planted in the fields, in well prepared earth, about three feet distant every way. Every morning and evening the plants require to be looked over, in order to destroy a worm which sometimes invades the bud. When four or five inches high, they are moulded up. As soon as they have eight or nine leaves, and are ready to put forth a stalk, the top is nipped off, in order to make the leaves larger and thicker. After this the buds, which sprout from the axils of the leaves, are all plucked; and not a day is suffered to pass without examining the leaves, to destroy a large caterpillar, which is sometimes very destructive to them. When they are fit for cutting, which is known by the brittleness of the leaves, they are cut with a knife, close to the ground; and, after laying some time, are carried to the drying shed, where the plants are hung up by pairs, upon lines, having a space between, that they may not touch one another. In this state they remain to

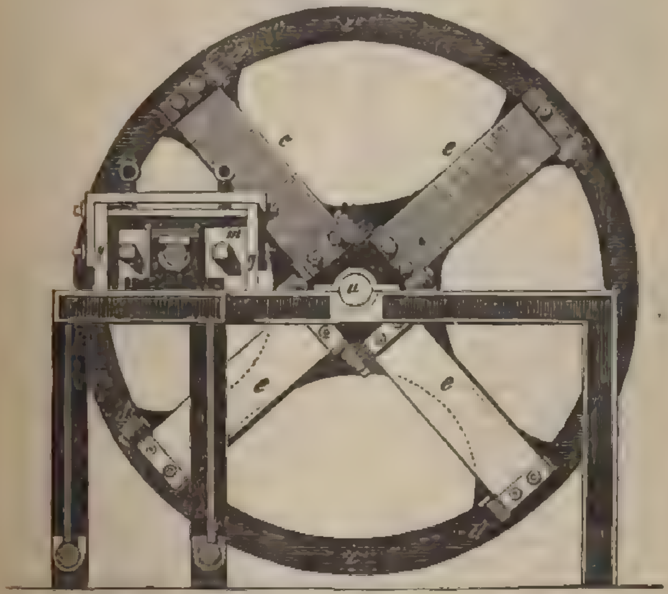
sweat and dry; when perfectly dry, the leaves are stripped from the stalks, and made into small bundles, tied with one of the leaves. These bundles are laid in heaps, and covered with blankets. Care is taken not to overheat them, for which reason the heaps are laid open to the air from time to time, and spread abroad. This operation is repeated till no more heat is perceived in the heaps, and the tobacco is then stowed in casks for exportation.

In the manufacture of tobacco, the leaves are first cleansed of any earth, dirt, or decayed parts; next, they are slightly moistened with salt and water, or water in which salt and other ingredients have been dissolved according to the taste of the fabricator. This liquor is called *tobacco sauce*.

The next operation is to remove the mid-rib of the leaves, which is reserved to be dried and ground for snuff. The leaves are then manufactured into a variety of articles, by rolling, twisting, and cutting; but the chief are the making of segars, and the cutting the leaves by a machine into fine shreds, for smoking with pipes, or chewing. The machine by which the latter operation is conducted is a very effective instrument, a knife being made to alternate vertically between grooves, with very great rapidity, while the tobacco leaves, confined in a channel, are gradually moved forward by a regulated quantity of motion under the operation of the knife, by which the shreds are uniformly cut of any required thickness.

A patent for an improvement in the machines used for this purpose, was taken taken out by Mr. Samuel Wellman Wright, in 1828. Instead of the alternating action of a single knife, Mr. Wright has introduced a series of knives, placed as radii to a wheel, which, as they revolve, cut the tobacco into shreds; much resembling in its action the chaff-cutting machine in general use, except that the knives in the latter have a curvature given to them, in order that they may

Fig. 1.

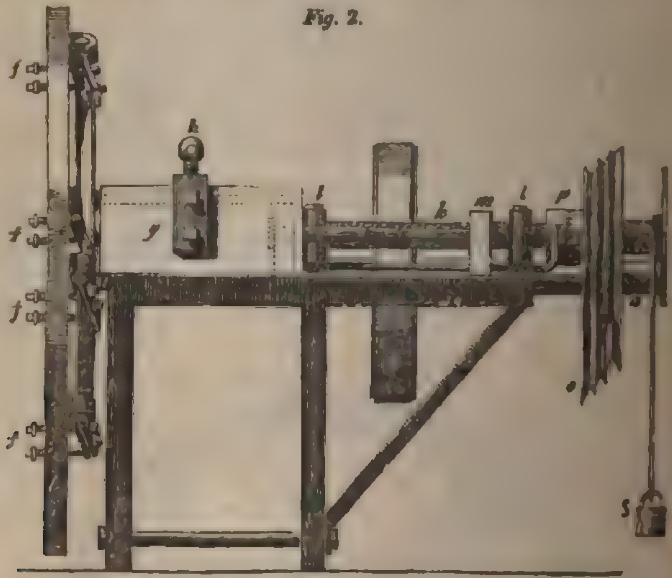


cut with a slicing action, and not with a chop, as in the machine we are about to describe, which may, however, be easily altered according to our suggestion.

Fig. 1, (above) and *Fig.* 2 annexed, represent two elevations or views of the

machine, one being at right angles to the other. *a* is the main axis, set in motion by the drum *b*; *c c* is a fly-wheel having hinges *d d*, to which the cutters *e e* are attached by screws, (these are best seen in *Fig.* 1;) other screws *f f* are employed to adjust and set the hinges *d d*, so that the cutters shall press close to the front of the box *g*, in which the tobacco is placed; *h h* are two screws for pressing the tobacco down; and *k* a screw, by the turning of which it is pushed forward towards the cutters. This screw is supported in plummer blocks *l l*, and works in a nut fixed in a massive block *m*, from which two strong bars proceed to another block in the box *g*, which presses the tobacco forward by the revolution of the screw. On the axis of the screw is a treble pulley, driven by a cat-gut band from another pulley *o*, on the axis of *a*, which admits

Fig. 2.



of the velocity of the screw being varied according as the tobacco is required to be cut fine or coarse. The treble pulley is made to carry round a screw by a sliding clutch *p* in the axis of the screw, which is kept pressed by a fork lying in grooves in the clutch.

When the box requires a fresh supply of tobacco, the fork is turned back from the clutch, and a weight *s*, which has been wound upon the axis of a winch *t* descends, and turning the screw in the reverse direction, brings back the block to the other end of the box *g*.

TODDY. A juice drawn from various kinds of palms, by cutting off such branches as nature intended to bear fruit, and receiving from the wound the sap designed for the nourishment of the future crop. This juice being fermented and distilled with some other ingredients, forms the celebrated spirituous liquor called *arrack* or *rack*.

TOMBAC. An alloy of copper, with about one-sixth part of zinc.

TOPAZ. A precious stone found in Saxony, Bohemia, Siberia, and Brazil mixed with other minerals, in granitic rocks. The yellow topaz of Brazil becomes red when exposed to a strong heat in a crucible; that of Saxony becomes white by the same process, showing that the colouring matter of each is not the same.

TOPOGRAPHY. A description or draft of some tract of land, as that of a city, town, villa, field, &c. as set out by surveyors.

RMENTOR. An instrument much used in tillage, sometimes for breaking the stiff clods, and at other times for skimming the surface turf, for the ·e of burning. It resembles a harrow in its general appearance, but runs wheels, and each tire is furnished with a hoe or share that enters and cuts ground.

RPEDO. A sub-marine apparatus, invented by Robert Fulton for the ·e of destroying ships. It consisted of a vessel or case, charged with ·tible matter, which he proposed to transfix by a harpoon to the bottom ·ship, by diving underneath it in his "nautilus," in which he sometimes ·ed under water for an hour at a time. Buonaparte employed him to ·his "infernal machine" to some British ships in the Channel; but Fulton ·in his attempts to fix his torpedoes; whereupon the impatient consul of ·rench republic regarded him as a quack, and dismissed him, unjustly ·ing, "Cet Americain était un charlatan, un escroc qui voulait seule·attraper de l'argent."

RTOISESHELL. The shell of the tortoise, a testaceous animal, used in ·brication of many articles of ornament and utility. The comb-makers ·rn-turners of France, Holland, and Germany, make use of the parings ·ppings of horn and tortoiseshell, in the manufacture of snuff-boxes, and ·ty of elegant articles and toys. They first soften the material in boiling ·so as to be able to press it into iron moulds, and then, by means of heat, ·them intimately into one mass. Care must be taken that the heat be not ·erful as to scorch the material; and grease must be carefully avoided, as ·revents their union.

URNIQUET. A surgical instrument employed to stop bleeding.

W. Coarse undressed hemp, or old rope reduced to the filamentous state.

AGACANTH. A gum, also called gum adracant, and gum dragon, is ·oduce of the above, and some other shrubs. The gum is brought to us in ·nd slender pieces, of a flatted figure more or less; and these not straight, ·ly so, but commonly twisted or contorted various ways, so as to resemble ·. We sometimes meet with it, like the other vegetable exudations, in ·ish drops, but these are much more rare. It is moderately heavy, of a firm ·ence, and, properly speaking, very tough rather than hard, and is extremely ·lt to powder, unless first carefully dried, and the mortar and pestle kept ·Its natural colour is a pale white, and in the cleanest pieces it is something ·arent. It is often, however, met with of a brownish tinge, and of other ·s still more opaque. It has no smell, and very little taste, but what it ·s disagreeable. Taken into the mouth, it does not grow clammy, ·tick to the teeth, as gum arabic does, but melts into a kind of very soft ·ge. It dissolves in water but slowly, and communicates its mucilaginous ·y to a great quantity of that fluid. It is by no means soluble in oily or ·ous liquors, nor is it inflammable. It is brought to us from the island of ·and from several parts of Asia. It is to be chosen in long twisted pieces ·whitish colour, free from all other colours, which must be rejected.

AMMEL. An instrument employed by artificers and draftsmen for ·g ellipses. It consists of a cross with two grooves at right angles to each ·and a beam containing two pins that are made to traverse in the grooves ·revolution of the bar; the bar carries a pencil that describes an ellipse.

ANSFERRING of engravings and lithographic drawings from the ·as to wood, or other material, is thus performed. The print is first ·in a vessel of water, until it is completely saturated, which will be in ·five or ten minutes, and then placed between blotting paper to remove ·perabundant water from its surface. It is then varnished by a brush, and ·immediately to the wood, which has been previously varnished and ·to dry. The print, thus applied, may be subjected to the pressure ·y to effect its complete adhesion, by spreading over it a sheet of paper, ·bbing this with the hand The paper on which the print was made may ·e peeled off by rubbing it cautiously with the moistened fingers, and when ·removed, a coat of varnish must be applied to the print. When coloured ·are to be transferred, an acid solution must be used instead of water, to

destroy the size which exists in the paper. This solution may be composed of two-thirds of vinegar and one-third of water, and is to be applied only to the back of the print. If the article is to be polished, apply several coats of varnish, allowing each to dry before the application of another; and then rub the surface with a piece of woollen cloth and pumice stone reduced to impalpable powder. When the surface becomes smooth, the process may be continued with a fine cloth, and the finest tripoli with olive oil.

TRANSPARENCIES. Is a term ordinarily applied to pictures, prepared with semi-transparent or translucent materials, and illuminated at the back, so as to exhibit them at night. The art of preparing them is as follows:—

The paper (or other material) must be fixed in a straining frame, in order to place it between the eye and the light, when required. After tracing the design, the colour must be laid on, in the usual method of stained drawings. When the tints are got in, place the picture against the window on a pane of glass framed for the purpose, and begin to strengthen the shadows with Indian ink, or with colours, according as the effect requires; laying the colours sometimes on both sides of the paper, to give greater force and depth of colour. The last touches for giving final strength to shadows and forms, are to be done with ivory-black or lamp-black prepared with gum-water, as there is no pigment so opaque and capable of giving strength and decision. When the drawing is finished, and every part has got its depth of colour and brilliancy, being perfectly dry, touch very carefully with spirits of turpentine, on both sides, those parts which are to be the brightest, such as the moon and fire; and those parts requiring less brightness, only on one side. Then lay on immediately, with a pencil, a varnish, made by dissolving one ounce of Canada balsam in an equal quantity of spirit of turpentine. Be cautious with the varnish, as it is apt to spread. When the varnish is dry, tinge the flame with red lead and gamboge, slightly touching the smoke next the flame. The moon must not be tinted with colour. Much depends upon the choice of the subject. The great point to be attained is a happy coincidence between the subject and the effect produced. The fine light should not be too near the moon, as its glare would tend to injure her pale silver light; those parts which are not interesting should be kept in an undistinguishable gloom; and where the principal light is, they should be marked with precision. Groups of figures should be well contrasted; those in shadow crossing those that are in light, by which means the opposition of light against shade is effected.

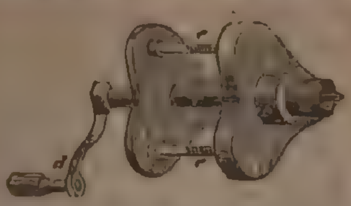
TREAD-MILL. Is a mill worked by the weight of persons treading upon the first movement, which is usually a wide cylindrical wheel, having upon its periphery a series of projecting steps or boards, resembling those of a water wheel. The weight of the individuals continually climbing these steps, causes it to turn round, and put in motion any other machinery, by means of ordinary gear. Tread-mills are now resorted to pretty generally in this country, as a means of prison discipline; and the result has been, that men cannot be found to work this species of machine out of prison, conceiving the employment to be degrading. The Chinese raise water by a similar contrivance for irrigation.

TREE-NAILS. Are cylindrical wooden pins or bolts, used to fasten planks to timbers, especially in ship-building.

TREPANNING. Is a surgical operation for opening the skull in cases of fracture; a description of which does not form a part of the plan of this work, and we only introduce the subject, in order to describe the instrument by which it is performed, as the principle of its construction may be advantageously applied to other purposes. *a* represents a thin steel tube, the edge of which is serrated into fine sharp teeth, forming thereby an annular saw; it is fixed to a stout brass collar *b*, which is adjusted to the end of the axis *c*, and revolves therewith, when turned by the winch *d*. There are three screw supports, *e e*, to the upper and lower plates, which form the frame, and the distance of the plates from each other is adjustable by the screws *e e*. The end of the axis is formed into a pointed drill, and extends a little beyond it.

The case which contains this instrument is provided with several sized annular saws, drills, and screws. The surgeons in using this instrument, (after removing

the scalp,) cut out a circular piece of bone, the central pin or drill it from slipping, and the perforation thus made by the drill serves



for the insertion of a screw, by which the removal of the circular ... is ensured. Access is thus gained under the arch of the skull ... the splinters or raising the depressed parts, occasioned by the ... Circular saws of this description have already been applied for ... pillars and concentric cylinders from solid blocks of stone; and ...cal readers will find out many other valuable uses for the applica... ...ular instrument.

...GLE. In geometry, a figure bounded or contained by three lines or ...which consequently has three angles, from whence the figure takes

...ULAR-COMPASSES. Are compasses with three legs, whereby ... any triangle at once; much used in the construction of maps,

... A small wheel carriage to be moved by hand; a species of barrow ...wheels; they are made in a great variety of forms, to adapt them to ...lar objects, such as the moving of sacks, bags, casks, cases, lead, iron, ...c, &c. &c. To describe those simple, well-known machines, would ... utility; we therefore confine our attention to a very ingeniously ...ruck, invented by Mr. S. W. Wright, and which is employed at the ... Dock Company's warehouses, for moving and stacking the sugar ...in tiers; an operation previously performed by other mechanical ... technically called "riding the hogsheads."

...ows the frame of the truck, mounted upon four wheels, on which it ... the skid upon which the hogshead is raised into the position repre... *d d* are levers supporting the skid, and turning upon fulcrums at *o o*, ...re attached two toothed sectors *e e*, that are acted upon by two ...ed near to the ends of the axis *f*: this axis carries a click-box *g*, ...orked by a lever *h* attached to it: *i* is a ratchet-wheel on *f*, *l* a pall, ...he same to prevent it receding; *m* a bent lever, for lifting by inter...ains, the palls, and click, which allows the skid to descend to the level ...r side of the frame *a a*; *n* is a handle for men to draw the truck. ...*two* ratchet wheels, and *two* palls, though only one can be seen in the ... view given.

...is employed to lift the hogsheads upon the truck; the latter is then ... to the pile, where the hogshead is raised by *alternately* raising and ... the lever *h*, which turning round the axis *f*, causes the pinions fixed ...raise the toothed sectors and levers that support the skid; a reaction ...ented by the palls falling into the teeth of the ratchet-wheels as they ... We object generally to an intermitting motion, where a continuous ... applied; and we can see no difficulty in applying it in the present ... the introduction of winches in the usual way. Notwithstanding the ...ections that may at present attach to this machine, it must be pro... original and effective contrivance; and so sensible (it was reported) ...irectors of the establishment before mentioned of the advantages ... the use of the new truck in their warehouses, as to present the ...ith the sum of *a thousand pounds*, over and above the amount of their ... a great many of the machines.

of all portable wind instruments; of which there ... most simple form, they consist of a metallic tube, ... aperture at one end for the emission of the sound, and ... adapted for blowing into it by the lips. See the ... SPEAKING-TRUMPET.

... wheel with staff teeth; also called a lantern or ... likewise given to the little carriages more generally ...

... short arms which project from the opposite sides of ... it is supported in its carriage, and becomes the

centre of motion upon altering its inclination. Trunnions are also employed in a similar manner to vibrating steam-engines, and in a great variety of other mechanism.

TRUSS. A term applied to many different things. In surgery, it is the bandage worn round the bodies of persons afflicted with hernia, or rupture. In sea affairs, it is a certain combination of pulleys, "to bowse the truss-pendants taught." In agricultural affairs, it is a certain bundle of hay, or straw, &c. The truss of hay weighs 56 lbs., and 36 trusses make a load. In commerce, there are trusses of other articles, in which the quantities vary.

TUBE. A hollow cylindrical body, made of metal, wood, or any other substance; the term is synonymous with PIPE; which see.

TUN. A large cask or barrel, which has probably derived its name from its capability to hold about a ton weight of ordinary liquids; or the measure of weight might be derived from that of capacity. A tun of vegetable oil is 236 gallons; of animal oil, 252 gallons; of wine, 252 gallons.

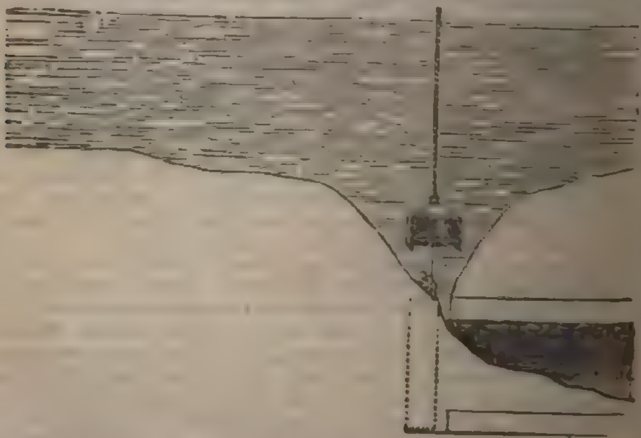
TUNGSTEN. A mineral found in Sweden, of an opaque white colour, and great weight; whence its name,—tungsten, or ponderous stone. This ore was analyzed by Schule, who found that it was composed of lime, and a peculiar earthy-like substance, which, from its properties, he called tungstic acid. The basis of the acid was found to contain a metal, which was named tungsten, and was obtained from the acid by charcoal.

TUNNEL. An artificial arch or passage under ground. They are employed as the means of conducting canals under elevated ground; for the formation of roads under rivers and canals, and in the construction of sewers and drains, &c., &c. Tunnels are now almost as common as canals and bridges. Amongst the many important works of this kind, may be mentioned, the *canal* tunnel under Standidge, between Manchester and Huddersfield, which extends under ground upwards of three miles, and is 220 yards below the surface. The *railway* tunnel under Liverpool. The *road* tunnel under the Thames, at Rotherhithe, which, although completed only half-way, is an undertaking of great national interest, and will, whenever finished, prove of great public utility. It is thirty-eight feet in width, and in the style of a double arcade, as shown in a sectional representation, which we shall have shortly to introduce. The work was commenced in 1825, by the building on the surface of the ground a circular brick tower, fifty feet in diameter, and three feet thick; this tower was gradually undermined all round, and sunk, until it rested on clay, forty feet below the surface; a wall was then built from beneath, to meet the kirb on which it stood, till from the depth of sixty-four feet, the shaft was completed, and a well formed seventeen feet deep, and twenty-five feet diameter, in the centre of the area, to serve as a receptacle for any water that might collect in the works, and which always brings it under the command of the steam-engine pumps. The shaft was then broken through, to commence the tunnel, in which, it is said, considerable difficulty was experienced. To give security and confidence to the men in excavating, Mr. Brunel invented a cast-iron shield or frame, of great solidity, so as to be capable of withstanding an immense pressure. Its extreme dimensions were thirty-seven feet in width, twenty-one feet six inches in height, and seven feet in depth, horizontally. This shield was divided into twelve perpendicular frames, and each frame subdivided into three stories, called cells or boxes. The utility of the framing consisted in its supporting the superincumbent weight, and in protecting and shielding the workmen employed from accident. One miner worked in each of the stories or cells, consequently, thirty-six men were enabled to pursue their operations at the same time. Each division had a roof of cast-iron plates, polished on the upper surface, so as to slip easily over the stratum of clay which rested upon it; and was supported by two strong cast-iron plates, called shoes, and which rest upon gravel at the base. The motion of each division was thus effected:—Each of the miners in the three cells excavated the ground in front of him, to the depth of nine inches, until the perpendicular height of the soil in front of the division, which was to be advanced, was excavated. He then supported the face of the soil by means of small planks called polings, and shut them with screws to the adjoining divisions, which were at

rest. The next operation consisted in unscrewing and slackening one of the legs, while the other supported the weight of the machine. The slackened leg was then advanced at two separate times to the length of nine inches, and then screwed up tight. When properly secured, the other leg was advanced, together with the shoes, in the same manner; and the division was then moved forward nine inches, by means of two horizontal screws and levers, one at the top and the other at the lower part of the division. One end of these screws was fixed in the frame, and the other abutted on the brickwork. Each of the divisions was moved in a similar manner, until the whole twelve were advanced nine inches, when the bricklayers immediately followed up with the brickwork and cement, building one brick in length in straight joints. This brickwork again formed an abutment for the horizontal screws; thus the work proceeded, alternately moving the machinery forward nine inches, and following it up with a course of brickwork in cement.

Notwithstanding these ingenious contrivances for ensuring the progress of the work (which reflect great credit upon the talents of the engineer), an irruption of water took place on the 18th of May, 1827; and as some account of the circumstances attending it may prove of importance to persons engaged in, or about to undertake, similar works, we shall here give it from the pages of a periodical journal published at the time.

For several weeks previous to the irruption of the water, it was discovered by the frequent descent of pieces of bone, brickbats, coals, &c., from the bed of the river to the works, that the earth, or rather the mud between the water and the tunnel, was exceedingly loose, and even at times in motion. Although much water had occasionally penetrated the works, the engine was found sufficient to remove it, and the work proceeded with very little interruption, till that time when the irruption of water between the shield and the brickwork was so great, as to oblige the men to make a hasty retreat, which they all did in safety. This irruption, which soon filled the tunnel, was much augmented by the action of the water on the last row of brickwork, before it was completed, and the cement had had time to set. On examining the bed of the river, after the accident, with the diving-bell, a spacious cavity was discovered over the spot, which terminated in a small hole, descending into the tunnel between the shield and the brickwork, as represented in the annexed sectional sketch. This hole, as



well as a second, which subsequently broke out in another part of the earth, was afterwards filled up with bags of clay, and large quantities of loose clay and gravel, thus making an artificial bed to the river; and this new-made part was protected from the effects of the tide, by a raft thirty-five feet square, sunk with a tarpaulin, covering, in all, about 8,800 square feet. After a while, the

ing having sufficiently settled, the water was drawn off by the
e workings recommenced: after clearing away all obstructions
ld, that piece of mechanism was found to be quite uninjured.
ent undertaking was, however, doomed to a second misfortune, of
character, which took place in January 1828, and was attended

ble loss of six lives. "The tide had just began to flow," says Mr
and finding the ground tolerably quiet, we proceeded by begin-
and had worked about a foot downwards, when, on exposing the
the ground swelled suddenly, and a large quantity burst through

the opening thus made. This was followed instantly by a large body of water. The rush was so violent as to force the man on the spot where the burst took place, out of the frame or cell, on to the timber stage behind the frames. A general retreat instantly took place; but the agitation of the air, by the rush of water, having extinguished all the lights, confusion ensued; the timber stage was thrown over by the torrent, knocking down under it several men, and the tunnel rapidly filled. Those who could get to the eastern arch effected their escape, while others were carried by the force of the current to the end of the shaft. Of eighteen men, besides Mr. Brunel, jun., who were thus placed at the mercy of the torrent in utter darkness, six were drowned, and the remainder, more or less injured, were taken out of the water for the most part in a state of extreme exhaustion. The foregoing wood cut, which affords a correct representation of the lamentable occurrence, is inserted principally on account of its

embracing an accurate longitudinal section of the tunnel, and of the mechanism of the movable shield on the left hand, through the upper part of which the

ance; the arched passages delineated in the back-ground, repre-
he entrances into the eastern arch, which is a parallel tunnel;
sages are continued at uniform distances throughout the whole
rk. One of the tunnels was intended for the traffic from the
th shore of the Thames, and the other for the traffic from the
th, to prevent interruptions; a flagged foot-path, as well as a
road, being made in both the east and west tunnels, as shown in
of the work in the lower part of the preceding cut, which we
explain.

deep interest taken by ingenious and scientific men for the pro-
tunnel, that soon after the *first* irruption, Mr. Brunel received,
port,) no less than 260 written plans, which, together with ver-
tions, made altogether 400 proposed remedies for the disaster.
there were some which displayed considerable ingenuity; and
ing to our information, was the following, which we insert, as the
he principle of its construction may hereafter prove of eminent
lling under a body of water. The inventor was a Mr. Garvey,
an active member of the London Mechanics' Institution,
gret to add, fell an early victim to the cholera in 1832. Mr.
s stated by himself, "consists in placing at the bottom of the
ver the part undergoing excavation, a large platform or raft,
eeding downwards to fix into the soil, to prevent the water from
cavation."

nd operation of this will be understood by reference to the
808, where S S represents a section of the tunnel; R the mud,
tituting the bed of the river; A B, the square platform, about twice
tunnel, consisting of two layers of planks, crossing each other
and made water and air-tight by a stratum of artificial leather,
her elastic waterproof material, between the layers; G G, and
sections of the ledges or rims, which may be made of iron, or
th iron; the platform must be loaded sufficiently to sink in water.
e escape of the air while the platform is descending in the water:
to draw off the water from under it, when it reaches the bot-
ing valves, to be opened or shut at pleasure, by the cords pass-
lleys *m m* and *n n*; the bent pipes *i i* are for the escape of the
m the space between the ledges G and H. When the apparatus
he bottom of the river, the water is to be removed from under-
mp E, which will produce a very great hydrostatic and pneu-
on its surface, and cause the points of the ledges, G and H, to
d of the river, and the whole to become firmly fixed in its place.
which extends of course all round the raft, is made conical, for
compressing the soil between the rims as they are forced down,
ing the entrance of the water at the edges.

paratus is to be moved forward to a new station, the pump E is
into a condensing air-pump, by changing the valves; and air is
er the raft till it is disengaged from the bottom, *when it can with*
forward in the water, and sunk as before.

d of the river is very irregular and gravelly, it may be necessary
put down clay in some parts before the platform is brought to

ibed that which is stated to have been the best of the
as acknowledged by Mr. Brunel to the inventor of it, the late
e shall proceed to notice that which was unfortunately adopted
The concavity in the bed of the river, and the hole through
rushed into the tunnel on the 18th of May, was first filled with
y and gravel; a large flat wooden raft, (*without ledges,*) was
he new-made ground, to prevent any sudden displacement of it,
ns afford a full protection to the workmen, when they might
avating *underneath.* The water, however, found its way under
powerful engine and pumps were employed for a considerable

period without lowering the level of it in the tunnel. The works were then half emptied of the water, when the force of the tide raised up one side of the raft, threw off the weights which had kept it down, when it floated up to the surface of the river. The ground in another part contiguous to the former hole now gave way, and the tunnel was again filled with water. Fresh quantities of clay and bags of clay were then employed to fill up the second hole; and the enlarged dimensions of the former, occasioned by a settling or movement of the artificial ground, was also filled up to a level with the natural bed of the river. The clay was covered with a stratum of gravel, and this by a large and thick tarpauling, which was kept down by cast-iron kintledge; another layer was thrown over the whole, to keep it as closely together as possible. Altho' this plan has proved an effectual remedy as far as it has been applied, the repetition of such remedies, whenever quicksand may be met with, or irruptions formed in the future progress of the work, must be attended with a wasteful expense. We therefore submit that Mr. Garvey's plan deserves the preference, as it may be shifted from place to place, as the work proceeds.

The lamentable accident which we described was also productive of an excellent plan from an eminent member of the London Mechanics' Institution, which consists in introducing, a few yards behind the workmen, flood-gates, so constructed, that the lower parts of the gates will be first shut by the water issuing in at the place where the work is carried on; and when the water rises nearly half way up, then to shut the middle parts of the gates; and when it rises near to the top, to shut the top parts of the gates. This arrangement would afford all the workmen time, who could reach so far as the flood-gates, to get safe out, and prevent the tunnel from being filled with water. This plan would not only tend to obviate much of the danger to be apprehended by the workmen, but greatly diminish the enormous expense consequent from such an accident. The small space between the shield and the flood-gates would soon become filled with mud and sand, and the bed of the river might then be soon made good from above, as then there would be no liability of the materials put down for that purpose being loosened, and removed, by the periodical ingress and egress of the water during the rise and fall of the tide. The cut on the next page exhibits a transverse section of the tunnel, with the gates, &c.

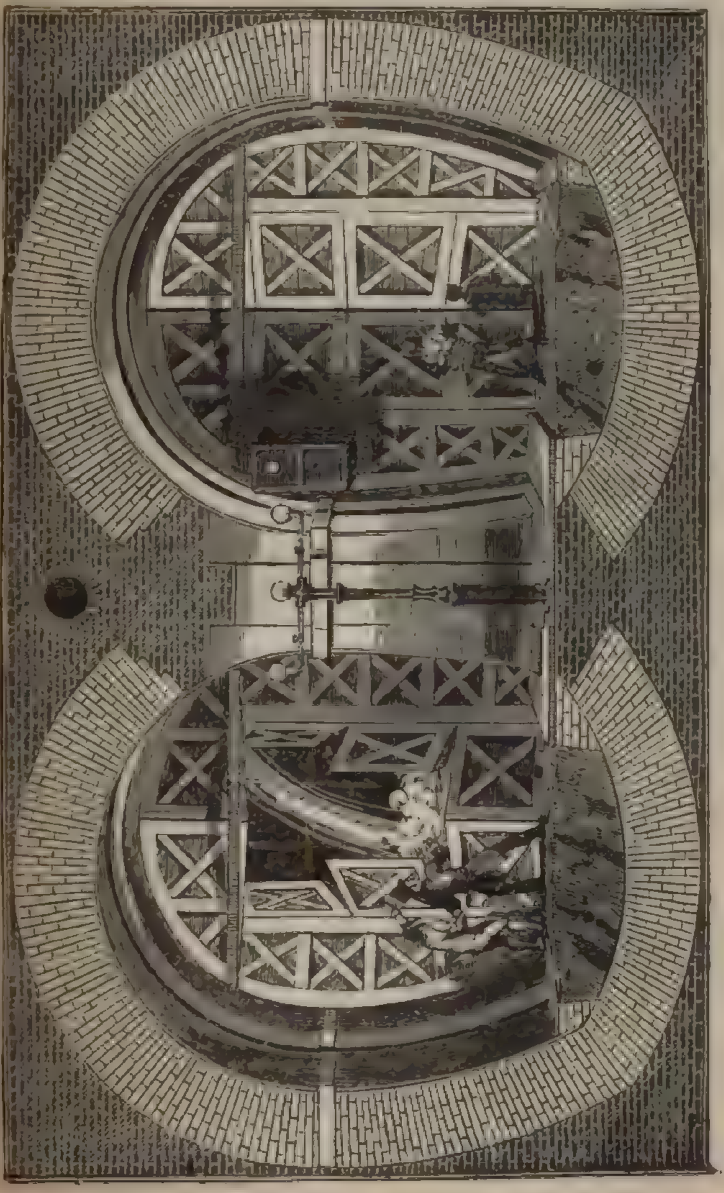
Fig. 1 represents a front view of the gates, with those on the right hand or eastern arch entirely closed, those in the other arch having been left open for taking through the clay and building materials, as the excavation proceeds. In order to make the plan better understood, the water is represented as coming in, which, having just closed the lower pair of gates, is in the act of shutting the middle pair, while the upper pair is represented as remaining open.

The lower pair of gates are beveled off to an acute angle, which terminates at the outside of the upper edge; and to correspond with this, the lower edges of the middle gates are beveled off in a contrary way, to lap over the others, as exhibited in the drawing. From this arrangement, it will be perceived that the middle gates will be partly in the water before it runs over the lower gates; and hence, the second gates will be shut as soon as the water begins to run over the first. The same arrangement is made with respect to the middle and upper gates, except that the upper edges of the latter are beveled to an angle on the inside, to fit a contrary bevel on the top of the gateway. It may be here observed that none of the flood-gates are made to open so far back as to become parallel with the side of the tunnel; consequently they are always in a situation to be acted upon by the water; and that the whole of the gates, as well as the framework in each arch, meet in the middle of the arch, as flood-gates on canals do, at such an angle as to afford the greatest resistance to the pressure of the fluid. To prevent the outward lateral pressure of the sides of the framing against the brickwork, and the injury it might thereby sustain, the opposite sides of the framing in each arch are connected by tie-beams, similar to those used in roofing.

It will not be necessary to make the whole area of the arch to open, as a comparatively small opening will be sufficient for conducting the operations

the miners. The opening gates are therefore represented as occupying only a small portion in the middle of the strong framing which fills up the arch.

Fig. 1.



It will of course be of the greatest importance that the threshold, or sills, against which the bottoms of the first gates shut, and for that purpose the portion of the road-way which passes through the gates, is so balanced and supported, that a very small portion of water accumulated under it will disengage its supports, and project part of the road-way or platform outside of the gates. The threshold may be further secured, if necessary, by a covering of canvas, so attached to the gates as to be rolled off by them in the act of shutting.

The joinings between the frame and brick-work, as well as the joinings round the gates, are made air and water-tight, by triangular packings of leather or other soft material, which are drawn into the crevices by a series of screw-bolts through to the outside of the gates, where the workmen can, at their leisure, screw the packing up after all the gates are shut.

The method of moving the gates forward, and of securing them in their places, is shown in *Fig*. 2, where *t* represents a vertical section of a set of flood-gates, supported in its place by three pair of strong beams, represented at *s*, fastened together at *r*; the other ends of these beams are attached to the flood-

Fig. 2.

gates, three on each side, at a small distance from the edge. The piece *s* rests upon a friction-roller or small wheel, and against a powerful screw-jack *o* which is supported by the abutment *p*, fixed into the bottom of the tunnel, and kept in its place by the vertical beam *q*.

When the gates are to be moved forward, the triangular packing round the edges of the frame must be released, and moved back, by unscrewing the bolts, which keep it in its place, and then the gates are forced forward on the small supports, on which they rest, by the screw *o*; and when they have been moved to their assigned place, the screw is returned into its box, and the abutments are brought up, and the whole apparatus again properly secured.

The box represented to the left of the eastern arch is sufficiently capacious to hold two or three men; it is provided with two doors, one of which opens into the box, and the other into that part of the tunnel which would be full of water when the flood-gates are all closed. The use of this box is for a man, harnessed in James's diving apparatus, to enter the part filled with water for the purpose of exploring and examining the works, and bringing out any thing of importance, requiring to be removed from the water. The man, having provided in his diving apparatus a sufficient supply of air for the time he intends to remain in the water, enters the box, and closes the door; he then, by means of a stop-cock, admits the water into the box, when the door between the box and the interior can be easily opened to admit him. In coming out, he has only to re-enter the box, shut the communication between the box and the interior, and then, by a stop-cock, let the water contained in the box issue into the open part of the tunnel.

This may be repeated as often as occasion may require, with very little

ter, and with perfect safety to the diver; for the ingress of the
tirely prevented by the flood-gates, it will be perfectly quiescent
and no danger is to be apprehended from a change or derange-
art of the works taking place during the miner's inspection. The
etween the shield and flood-gates would soon be filled, when all
stationary; and consequently the principal cause of damage to
e rushing of a large quantity of water with great violence, would
If it should be objected, that the time occupied in filling the space
ates and the shield would be too short to allow the workmen to
y be answered, that very little time would be required for all the
et outside, where they would be perfectly safe, and might leisurely
ress of the water in filling the space, and closing the gates: besides,
of the water, under such circumstances, would be of so little conse-
here would be no occasion for detaining the men in attempting to
nt, till their lives are in danger. The water within being perfectly
of the river might be made good, the water pumped out, and the
e going on again, in the course of a day or two after an irruption,
such means as are herein described.
iod we are writing, (February 1835,) the work at the Thames
stand. A brick wall has been completed at the further extremity
tion, which is made water-tight, and the interior of the tunnel is
hough no accidents had happened.
A mixture of earth with the roots and leaves of plants, partially
it is used as fuel in many parts of the country. See PEAT.
IC, or INDIAN SAFFRON. A root brought from the East Indies,
in making a yellow dye. The colouring matter it yields is very
of great brilliancy of tint; but it possesses no durability, nor
rdants yet been discovered sufficiently powerful to fix it. Common
monia have been recommended for this purpose; but they are
en the colour, and incline it to brown.
G. The art of giving circular and other forms to solid substances,
tion of innumerable articles, by the aid of a machine called a
e is perhaps no contrivance with which human ingenuity has aided
of the mechanic more entitled to our admiration than the lathe;
en we take into the account all the improvements it has undergone,
dest and most ancient form in the potter's wheel, to that adaptation
complex mechanism, by which not merely circular turning of the
l and accurate description, but exquisite figure-work, and compli-
trical designs, depending upon the eccentric and cycloidal
re daily produced.
tion of turning differs very essentially from most others, in the
that the matter operated upon is put in motion by the machine,
t by means of edge tools, presented to it, and held fast; whilst in
the work is fixed, and the tool put in motion. In ordinary
ork is made to revolve on a stationary straight line as an axis,
tool, set steady to the outside of the substance in a circumvolution
off all the parts which lie farthest from the axis, and makes the
t substance concentric with the axis. In this case, any section of
de at right angles to the work will be of a circular figure; but there
of turning ellipses and various other curves, distinguished by the
ine-turning.
made in a great variety of forms, and put in motion by different
are called *centre lathes* where the work is supported at both ends;
dle, or *chuck* lathes when the work is fixed at the projecting
a spindle. From different methods of putting them in motion,
lled *pole*-lathes, and *hand-wheel* lathes, or *foot*-lathes; for great
re turned by horses, and water-wheels, but more generally by steam-
e lathes used by wood-turners are usually made of wood, in a
and are called *bed*-lathes; the same kind will serve for turning
ls: but the best work in metal is always done in iron-lathes, which

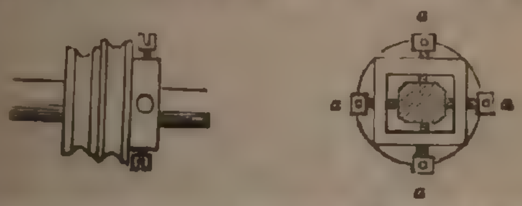
are usually made with a triangular bar, and are called *bar*-lathes. Small ones, for the use of watch-makers, are denominated *turn-benches*; but there is no essential distinction between these and the centre lathes, except in regard to size, and that they are made in metal instead of wood, and the workmanship being more accurate and better finished.

The centre lathe is now very little used but by country turners, to make articles of household furniture in soft wood, as table-legs, staircase-rails, bed posts, &c. It consists of the following parts: 1st. The *bed*, which is composed of two beams bolted together at a small distance asunder, and parallel to each other; it is supported horizontally on legs at the ends, and forms the support of the whole; the *groove* is the narrow opening between the two halves or cheeks of the bed, to receive the tenons of the *puppets*, which are two short upright posts fastened down upon the bed at any place by means of wedges, driven through mortices in the tenons of the puppets beneath the bed; one of the puppets has a *pike* or pin of iron fixed into it, and the other one has at the same level the *centre-screw*, working through a nut fastened in the puppet, both the screw and the pike have sharp points made of steel, and hardened and tempered that they may not wear away; they must be exactly opposite, and in a line with each other. The piece of wood which is to be turned, suppose, for instance, a pole of wood, is supported by its ends between the points of the pike and the screw, that it may turn round freely, and the screw is screwed up, till it has no shake. The puppets can be placed at any distance asunder according to the length.

The rest is a rail or bar, extending from one puppet to the other, for the support of the tool; it lays in hooks projecting from the faces of the puppets, the work is put in motion by means of the *treadle*, which is worked by the turner's foot; the string or cat-gut is fastened to the treadle, and passing two or three times round the work, it is fastened to the end of an elastic pole, fixed to the ceiling over the turner's head: now as the turner presses the treadle down by his foot, the string turns the work round, and a sharp chisel or gouge, being held against the wood upon the rest, will cut the wood to a circular form. When he has brought the treadle to the ground, he releases the weight of his foot, and the elasticity of the pole draws up the treadles, turning the work back again; during which retrograde motion he withdraws the chisel from the work as it would not cut in this direction through it, and might impede the motion of the wood; and the pole is fastened to the ceiling of the room, where the lathe is placed by a pin, upon which it can be turned about as a centre, and it rests upon a horizontal bar fixed at some distance from the centre: it is placed in a position nearly perpendicular to the axis of the work, so that, when it is turned upon its centre pin, the string at the other end may be brought over any part of the length of the work where it will be most convenient for the turner to have the string put round it: in the same manner the end of the treadle is placed, with one end over a centre pin in the floor, that its opposite end may be moved under the work to the proper place for the string. It is held in this position, while moving up and down, by a second treadle, perpendicular to the first, which moves in a loose centre on the floor at one end, and the other is perforated with a number of holes to receive a pin fixed in the first treadle, and thus to confine the treadle to move up and down under any place it is set to: the end of the principal treadle is turned in the lathe, and made like a pulley, to hold the line or string which is wound upon it, and the turner winds the string on or off this end of the treadle, to adjust its length to the diameter of the work round which the string passes; the string is fastened to the end of the spring-pole in a similar manner. The workman stands, or is seated before his lathe, having one of his feet on the treadle to give the motion; it must be very moderate and equal; he places his tool on the rest, and approaches the head of it gently to the piece, performing his work gradually without leaving any ridges, and when he meets with a knot, he must go on still more gently, otherwise he would be in danger both of splitting his work, and breaking the edge of his tool. For turning light work, a bow, such as is used for shooting arrows, is suspended by its middle over the lathe; the

ring is then tied to the middle of the bow-string instead of the pole, and acts the same manner. The continued rotary motion given by a wheel is so ich superior for turning to the reciprocating motion of a treadle and string, at regular turners seldom make use of the latter; yet the simplicity and eapness of the whole is a great recommendation, especially among country rkmen, who are not so careful of their time as in the towns, where mpetition obliges every one to use the best and quickest means of despatch- g his work.

The common centre-lathe becomes a powerful machine when worked by ans of a large wheel, turned by one or more labourers; the wheel should be avy, that its momentum may be sufficient to overcome any trifling obstacle in e work, and the frame in which it is mounted must be of sufficient weight to ad steady, and not be liable to move by the exertions of the man turning it. n endless line is used to communicate the motion of the wheel to the work; passes round a groove in the circumference of the wheel, and, after ssing like a figure of 8, goes round a small pulley fixed upon the work; by s means, when the great wheel is turned, it gives a rapid rotary motion the matter to be turned, and with a much greater power than can be tained from the treadle, with the additional advantage of the work turning ways the same way round, so that the turner has no need to take his tool off work; the small pulley is perforated with a square hole, to receive a square ale on the end of the work, and the turner has many different pulleys, each h a different sized hole through it, to suit work of different diameters; but re is an inconvenience attending this method, for if the four corners of the are on which the pulley is fitted be not all equally distant from the centre the work, the pulley will not turn round truly, and the band will be liable to round upon it. To obviate this, the pulley in the annexed figure is often



d; it has a square hole through it to receive the work, and is made to fit upon means of four screws *a a a a*, passing through a part of the wood by the of the pulley, and their point pressing into the work; in this manner one or pulleys can be made to serve work of any dimensions, and can always be truly upon it; it has, as shown in the edge view, two different sized grooves, ther of which the band may be worked when required

There is a kind of centre-lathe, which is generally employed by millwrights iron-founders, in turning heavy metal work, such as the gudgeons of mill- ts, rollers for sugar or rolling-mills, pump-rods, which are to pass through ing-boxes, or, in short, any work which will admit of having both its ends orted on centres; it is in many respects similar to that we have described, is adapted to give a continued rotary motion to the work; it has legs which port it from the floor, and the bed is formed by two parallel beams or cheeks, ed to the legs; one of the legs stand up above the bed to support the main, ft-hand centre point, instead of having a puppet on purpose. The centre is fastened into it, by a nut and screw behind, and upon this pin two wooden eys are fitted side by side, close to each other, so that they appear but one; e of these, at pleasure, is caused to turn round by means of an endless strap, g round a drum, extending over head or under the floor, and which is ed by horses, or a steam-engine; the strap being only the breadth of one of pulleys, will turn but one of them at a time, but it can easily be shifted one to the other at pleasure, and then the other will stand still. The front of these pulleys gives motion to the work.

The back puppet is fixed upon the bed of the lathe, by a tenon projecting downwards, and entering the space between the two chucks of the bed; it is fixed at any place, by means of a screw-bolt, which passes down through the puppet and goes through a piece of iron, which takes its bearing on the under side of the bed; a nut is fitted in this screw, and thereby the whole puppet can be drawn down upon the cheeks so firmly that it will not move by any strain the work may occasion: the back puppet has a back centre screw, which has a steel point to support the work.

The work is turned about in this lathe by means of an iron pin, projecting some inches from the flat surface of the front pulley, which, as before mentioned, is fitted on the centre point: a piece of iron, called a driver, is screwed upon the work near its left hand end, so as to project perpendicularly from it, and the pin in the pulley intercepts this as it turns, carrying the work round with it.

The other pulley, which is fitted on the centre pin, is only of use when the lathe is wanted to stand still, in the same manner as the live and dead pulleys used in cotton-mills. When the workman wishes to put the lathe in motion, he presses the handle of his tool, or any other smooth piece of wood, against the edge of the endless strap while it is in motion, and pushes it towards the front pulley; in a very short time the strap will get completely on the pulley, and shift itself to a fresh place on the drum corresponding to the pulley; this causes the pulley to turn round, and by the pin pushing round the end of the driver screwed on the work, communicates its motion to the work to be turned. When he wishes the motion to cease, for the purpose of examining his work, he pushes the strap back again on to the other pulley, which has no communication with the work, as it slips freely on the centre pin: the driver is simply an iron ring, having a screw tapped through one end of it, to pinch the work so fast as to prevent its slipping.

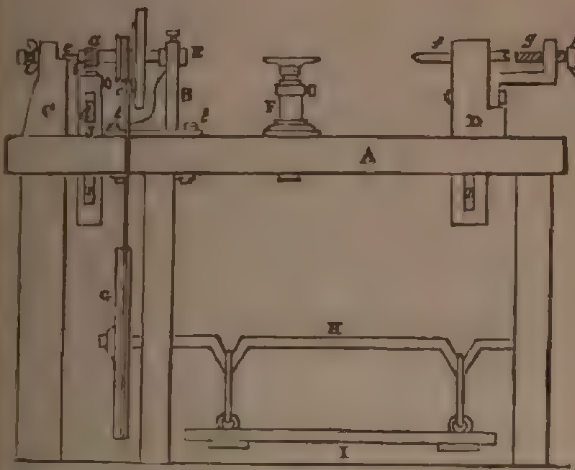
The side opposite the screw should be angular, that it may fit any sized work; this driver may be fixed on either end of the work, while the other is turning, but when it is necessary to fix the driver on that part of the work which is finished, the end of the screw is apt to pinch and bruise it; it is therefore proper to use a driver composed of two bars of iron screwed together by two screws, passing through one bar tapped into the other; both bars are somewhat hollowed out in the middle, that they may encompass the work. If this should be found to injure the work, a piece of sheet-lead wrapped round it before the driver is put on, will prevent the possibility of its damaging the work, and if the screws of the driver are drawn very tight, it will carry the work about with sufficient force to bear turning.

The manner of mounting and giving motion to a piece of work in the centre lathe is thus:—the back puppet is first fastened on the bed of the lathe, at the proper length to receive the work; the workman then places one of its ends against the points of the front centre, with the points as near the centre of the work as he can guess; he then brings the centre of the other end of the work opposite the point of the centre screw, and screws it up so as to hold the work just tight enough to prevent its falling down. In this state by turning it round by one hand, while he holds a piece of chalk against it with the other, he finds whether it is pitched nearly concentric on the points; and if it varies much any points, he turns back the screw and tries again, observing to shift the centre-point nearer towards that side which appears to project farthest in revolving, and therefore gets marked with the chalk. When he has found the true centre, he screws up the point so hard that it may mark the end of the work; then, taking the work out of the lathe, he punches or drills holes in the end, where the screw and centre points have marked, and when the work is returned into the lathe it will run nearly concentric; the driver being screwed fast on either end of the work as is most convenient, the work will be turned round by the pin projecting from the pulley as before described. The turning of heavy iron-work, for which these lathes are used, is performed by various tools chiefly called hooks, but these will be further described.

The centre lathe will perform any kind of work which can be turned upon centres made in the ends of it; but a great portion of the articles formed in the

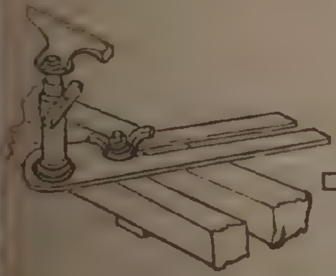
, must have one of their ends at liberty, to be operated upon while they are ing, as cups, boxes, and all kinds of hollow articles; these are turned in *he foot lathe, with mandril and collar.*—A lathe of this kind serves equally for centre work; therefore if the professed turner is without a mandril lathe, of these constructed in the simplest and most economical manner, and chiefly ed, that the artificer may be enabled to make it himself, is shown in the xed figure.

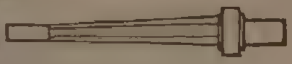
Fig. 1.



is put in motion by a foot-wheel and treadle, so that the turner has both at liberty for directing the tools. A is the bed of the lathe, consisting o beams or cheeks, fixed parallel to each other, and leaving a small space

Fig. 2. *Fig.* 3.





en them, as shown in *Fig.* 2. The bed is supported by three upright legs, wn in the figure; one of these projects above the bed a sufficient height to one of the puppets C, for the support of the extremity of the spindle or il *e* E; the other end is supported in a collar fixed in an iron standard ppet B, which is screwed down upon the bed, by two bolts marked *t t*. The puppet D has a tenon which is received through the bed, by which it can

be fastened at any place; f is the back centre pin, fitted through the puppet; and g is a screw situated behind it, to advance and keep it up to his work. The mandril is turned round by a band of cat-gut passing round the pulley c, and also round the large foot-wheel G, which is made of cast iron, and fixed on the end of the axis H; this is bent as in the figure, to form two cranks, united by two iron links to the treadle I, on which the workman presses his foot; this treadle is affixed by two short boards to an axis on which the treadle I moves. The wheel G is of considerable weight in the rim, and being wedged fast on the axis turns round with it; it is the momentum of this wheel that continues to turn the work while the crank and treadle are rising, and consequently while the workman exerts no power upon them. When the crank has passed the vertical position, and begins to descend, he presses his foot upon the treadle, to give the wheel a sufficient impetus to continue its motion until it arrives at the same position again.

The length of the iron links, which connect the cranks with the treadle I, must be such that when the cranks are at the lowest, the board I of the treadle, to which the links are hooked, should hang about two or three inches from the floor. The turner gives the wheel a small turn with his hands, till the cranks rise to the highest, and pass a little beyond it, then by a quick tread he brings the cranks down again, putting the wheel in motion with a velocity that will carry it several revolutions; he must observe to begin his next tread just when the cranks pass the highest point, and then it will continue running the same way with a tolerably regular motion, if he is punctual in the time of his treads.

The rest which supports the tool while it is in the act of turning, is made of iron, as shown in *Fig.* 2; it is supported on the bed of the lathe by its foot, which is divided by a groove in the manner of a fork, to receive a screw bolt, going down through the lathe-bed, and fastening it at any place along it by a thumb-nut; the groove in the foot is for the purpose of allowing the rest to be moved to and from the centre of the lathe, to adjust it to the diameter of the work which is turning. The height of the rest is of some importance in turning; and for some work it should be fixed higher than others; therefore the shank of the cross piece, or T, upon which the tool is laid, is received into a socket in the foot of F, and can be held at any height by a screw. As the socket is cylindrical, the edge of the rest can be placed inclined to the axis of the work, when turning cones, or other similar work; though the same purpose may be accomplished by the screw which holds the foot of the rest down to the bed of the lathe, admitting it to stand in an oblique direction.

The mandril or spindle is the most important part of the lathe; it is made of iron, in the manner shown at *Fig.* 3; but the two extremities are of steel, which are hardened after being turned and finished; the small end has a hole made in it to receive the point of a screw, which, as shown at e, *Fig.* 1, supports the end of it; the other end of the mandril is made larger, and has a hole within it, cut with a female screw, for the purpose of fixing on the various chucks by which the work is turned; the outside surface of the end is turned extremely true, and is fitted in a brass collar at the top of the standard B; one of the bolts, marked t, which fasten the standard down, goes through a stout iron plate, situated beneath the bed, passing between the two wooden cheeks. In the top of the standard is a square hole, for the reception of two pieces or dies of brass which include the mandril between them; these are kept in their places by a piece of iron i, fastened down by screws l l; and m is a screw tapped through this, which presses the two dies together, and thus adjusts them to receive the neck of the mandril without any shake. The screw which supports the other extremity of the mandril fits in two iron or brass nuts, which are let into the back and front of the wooden puppet C, and by turning this, the mandril can be adjusted to run very correctly in length; to prevent the screw from turning back when the lathe is in motion, a nut is placed on the screw outside of the puppet, and after the screw is turned by its head to fit and hold up the mandril, the nut is screwed firmly against the nut which is let into the outside of the puppet; this causes such a pressure upon the threads of the

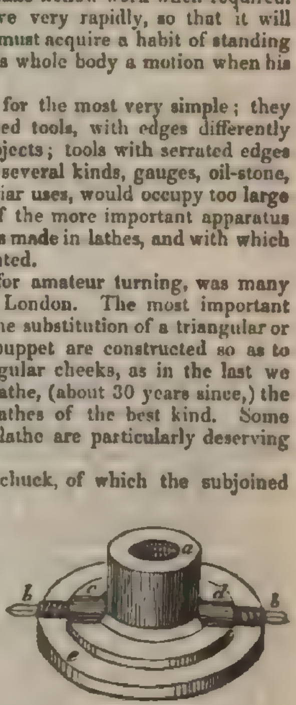
screw, that it is in no danger of turning back, as it would otherwise be liable to do with rough work.

The mandril by this means runs very steady and accurately in its bearings; and it is plain that any piece of work being firmly attached to the end of it, by means of the screw before-mentioned, may be turned by a tool held over the rest, in the same manner as if it was mounted between centres, but with the advantage that it be turned at the end, to make hollow work when required. The foot-wheel causes the mandril to revolve very rapidly, so that it will perform its work very quick, and the workman must acquire a habit of standing steady before his work, that he does not give his whole body a motion when his foot rises and falls with the treadle I.

The tools used in turning are numerous, and for the most very simple; they consist chiefly of chisels and gouges, and hooked tools, with edges differently beveled, so as to adapt them to their peculiar objects; tools with serrated edges for cutting solid and hollow screws; callipers of several kinds, gauges, oil-stone, &c. To describe all these things and their peculiar uses, would occupy too large a space; we therefore proceed to notice some of the more important apparatus and improvements which have been of late years made in lathes, and with which some of our readers are perhaps not yet acquainted.

A very elegant and useful lathe, especially for amateur turning, was many years ago made by Mr. Henry Maudslay, of London. The most important feature in this improved turning machine, was the substitution of a triangular or prismatic bar, upon which the rest and centre puppet are constructed so as to slide, instead of sliding between parallel rectangular cheeks, as in the last we described. Since the first introduction of this lathe, (about 30 years since,) the triangular bar has been universally applied in lathes of the best kind. Some of the appendages introduced with Maudslay's lathe are particularly deserving of attention.

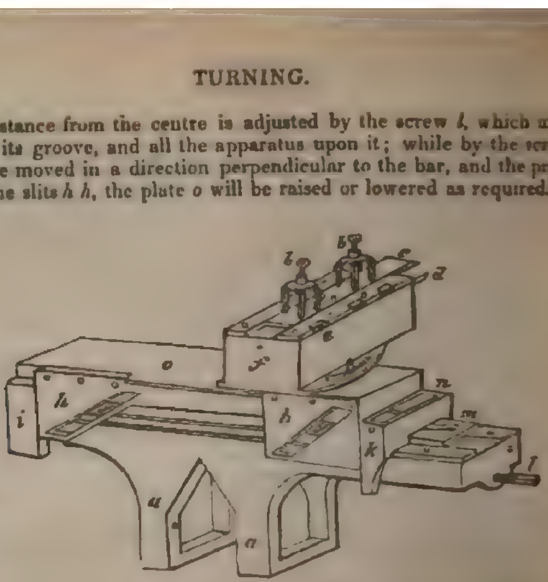
The first we shall describe is the universal chuck, of which the subjoined figure will convey an accurate conception.



At *a* is a hollow screw, at the bottom of which is another screw, *b b*, which is prevented from moving endwise by a collar in the middle of it. One end of the screw is cut right-handed and the other left-handed; so that by turning it one way, the nuts *c d* will recede from each other, or by turning it the contrary way, they will advance towards each other. These two nuts pass through grooved openings in the plate *e*, and project beyond the same, carrying jaws like those of a vice, by means of which the substance to be turned is held.

Another very important and useful appendage to Mr. Maudslay's lathe, was his slide rest, which instrument is now universally employed in the best kind of lathes, for turning the faces of wheels, hollow work, and numerous other purposes. Since its introduction it has received many valuable modifications. It is represented in the subjoined engraving. At *a a* is a triangular opening to receive the triangular bar before mentioned, which is closed against the lower surface of the bar by means of clamps and screws, not represented. The tool for cutting is fixed in the two holders *b b*, by their screws; these holders are fastened by a sliding plate *c*, which can be moved backward and forward by the screw *d*, causing the tool to advance or recede. When it is necessary, as the turning of the insides of cones, &c., that the tool should not be parallel to the spindle of the lathe, the screw at *e*, and another similar one behind, must be loosed, so as to allow the circular plate under the box *f*, to turn upon its centre. Near the four upper corners of the lower portion of the rest are small projections, two of which *g g* are seen; they have inclined sides, and fit into corresponding angular openings *h h* of the upper part of the instrument, which slides or rises between the piece *i* and the base *k*, in such a way as to prevent any other than a vertical motion. When this slide tool is placed on the bar to be

used, the distance from the centre is adjusted by the screw *l*, which moves the slide *m* in its groove, and all the apparatus upon it; while by the screw *n* the slide may be moved in a direction perpendicular to the bar, and the projections acting in the slits *h h*, the plate *o* will be raised or lowered as required.



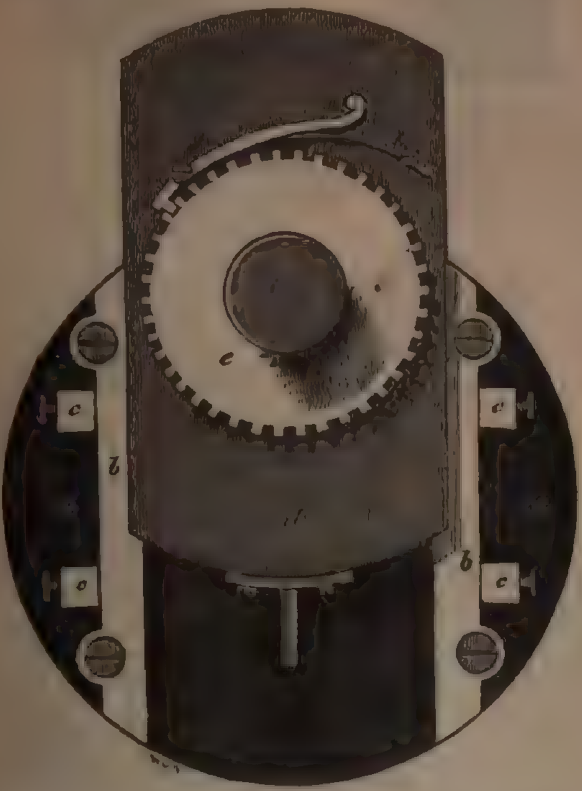
Such lathes as we have already described, are not well adapted to the turning of long rods and cylinders, such as are required in large steam-engines and various massive machinery, on account of the necessity of repeatedly shifting the rest, and the difficulty of keeping the work perfectly uniform in thickness through a considerable length. Engineers therefore facilitate the turning of such surfaces by means of another machine called a slide lathe, by which the work is performed with great ease and exactness. The principle of this invention consists in so constructing and attaching the body or carriage of the rest, that instead of being screwed down to one place during the operation of the tool, and requiring to be advanced at intervals as the work proceeds, it shall slide along the surface of the bench in a direction parallel to a line drawn through the centre of the spindle. At the same time the tool, instead of being merely held upon the rest with the fingers, is firmly fixed in its proper position by screws, so that it can neither be driven off without taking effect, nor yet be drawn by its keenness so as to spoil the work. The whole is managed in such a way that, as the iron to be turned revolves between the centre points, the rest, with its cutter or chisel advances slowly along in a certain direction, so as to produce a perfectly level rod. But besides the exactness attainable by this method, there is likewise the advantage of economy; as one man, who would with hard labour apply the tool to one point at once at a common lathe, may easily attend to, and keep in work, two or three slides.

The degree of velocity with which the surface of an article being turned ought to pass the edge of the tool so as to be cut by it, differs materially in relation to different metals. Cast-iron, in consequence of its open grain, and containing as it generally does many impurities, is required to revolve very slowly, so as to pass the edge of the cutting tool only at the rate of about 100 feet per minute; wrought iron and steel are usually turned when revolving at a rate of about twice as quick; and brass cuts well when coming in contact with the chisel at the rate of about 300 feet per minute. To produce the requisite velocity according to the material or size of the work, pulleys of different diameters are fastened on the spindle, as already stated; so that the larger the work, the larger the pulley, and *vice versâ*.

Mr. Ibbetson, an amateur turner of great celebrity, and the author of a pretty book on eccentric turning, has made many improvements in the mechanism for ornamental turning; his eccentric chuck is exhibited in the annexed figure.

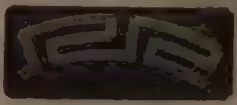
a a is a plate of brass of sufficient solidity, on which are fixed two slides of steel *b b*, by means of screws; the holes which admit the screws are made a

little oval to enable the slides to move nearer to, or farther from, each other, if necessary; *c c c c* are four pieces of metal firmly fixed to plate *a*, and having a screw in each, which presses on the slides *b b*; *d* is a plate of metal or brass, sliding between *b b* in a dovetail, and must be made to fit very accurately when



the slides are parallel to each other, and is moved between the slides by means of a screw working in a slot made in the plate *a*, and which regulates the eccentricity, as it moves the plate *d*, either nearer to, or farther from, the centre of the chuck. *e* is a circular plate, whose edge is cut into teeth, and which is capable of being turned round its centre, and is held in any position by the catch *g*, which falls in between the teeth, and is held in its place by a spring *h*. On the centre of the wheel *e* is fixed a screw *f*, (exhibited by the shadow thrown on the wheel,) whose threads correspond with the screw of the mandril of the lathe, for the purpose of fixing any chuck, on which is fastened the substance to be turned. To this chuck Mr. Ibbetson has adapted a slide-rest, of a peculiar description, as well as his lathe and other appendages thereto, for an explanation of which we must refer the reader to his work, entitled *Specimens in Eccentric Circular Turning, with Practical Instructions for producing corresponding Pieces in that Art*, published by Wetton, Fleet-street. This work is illustrated by upwards of sixty copper-plate engravings, and imitations of wood-cuts of a superior description; and it is due to the ingenious author not to omit noticing, that they were *all produced in the lathe by himself*. In the following page we give a

copy of two of the figures of the simplest combinations of circles, to which, as well as to all others, the author has annexed plain practical instructions, so that the



novice may proceed step by step to produce the same figures by turning the screws of the slide-rest and the eccentric chuck through prescribed spaces, and from these simple figures, by similar successive operations, he may proceed to the most elaborate and beautiful designs.

Fig. 1.

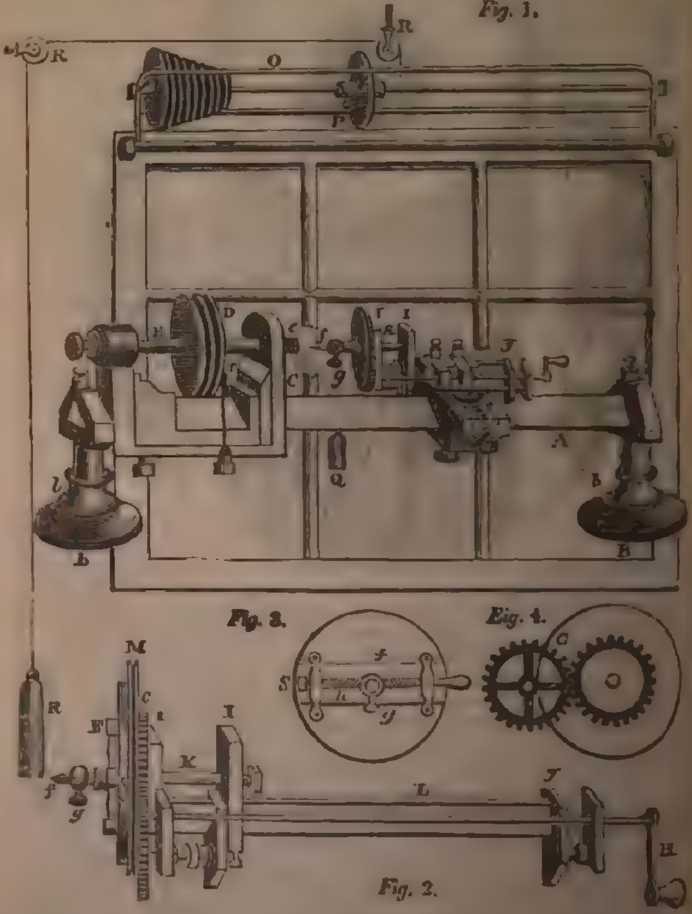


Fig. 3. Fig. 4. Fig. 2.

We shall now add a description of Mr. W. E. Wightman's (of Maldon, Yorkshire) excellent lathe, as explained by himself in a periodical journal

feeling assured that it may prove of the most eminent service to mechanics, as the arrangements are extremely simple and easily understood, and the construction such as any tolerable workman can accomplish, and avail himself of the advantages it offers, at a moderate cost.

"*Fig.* 1 represents the lathe, with the cutter-frame fixed in the compound sliding rest, ready for use. A, the triangular bar on which the machine is mounted. B B, two pillars, which support the bar; the parts *b b* fix it to the lathe-frame. C, the left-hand head; D, the pulley; E, the mandril; *e*, the screw on which the chucks are fixed; F, the cutter-frame; *f*, the cutter; G, two wheels, which give a slow motion to the cutter-frame; H, the rod and handle of the slow motion; I I, two heads or puppets, in which is fixed the spindle K, of the cutter-frame; L, a bar of steel, on which the puppets are fixed, and which also fastens the cutter-frame to the compound sliding rest, by passing it through a hole in the tool-frame, as will be seen, on reference to the figure, the part *y* removing for the purpose; M, a groove turned on the edge of the cutter-frame, for the string N to work on; O represents the frame for double stringing the lathe; P, a movable pulley, whereby it may be fixed perpendicularly over the cutter-frame; Q, a weight attached to a pulley behind the bar, for keeping the string N tight; R R R, the pulley's string and weight connected with the frame O, for double stringing the lathe; T, the index to the division-plate; S, one of two screws for changing the rectangular position of the compound sliding-rest to an oblique. S, *Figs.* 2 and 3, represents the slide of the cutter-frame; and *h*, *Fig.* 3, the screw, whereby the slide is moved; *g*, the screw for fastening the cutter. *Fig.* 2, is an enlarged view of the cutter-frame, when removed from the rest. *Fig.* 3, represents the face of the cutter-frame. *Fig.* 4, the back of it, with the wheels of the hand-motion. The letters refer to the same parts in all the figures.

"This machinery is intended to supersede the use of the eccentric chuck, by assuming a more natural and easy method of engraving, by the tool or cutter tracing the work, instead of the article doing it, that is to be ornamented. By this improvement, the action of the tool is more distinctly seen, than could be, by the movement of the chuck, especially after a few circles have been cut; for, by their rotation, the eye (particularly of an amateur) is soon fatigued, and yet to these inconveniences a turner must continue to submit, if no better method could be contrived.

"The principal advantages of the present invention, are the following. At a comparatively trifling expense, (to the costly machinery now in use,) a turner may be put in possession of an apparatus, which will answer all the purposes of eccentric and cycloidal turning, and which will, at the same time, form a complete drilling frame. As an apparatus intended to supersede the use of the eccentric chuck, it combines many advantages, amongst which, three may be mentioned that are of importance:—1st, As all patterns are worked by the divisions of the plate on the small wheel of the lathe, a much more extensive variety of circles can be obtained, than could be by the divisions of the eccentric chuck. 2d, By slackening the screws *s s*, in the large slide of the compound sliding-rest, a change may be effected from the rectangular position of the cutter-frame, to an oblique position; and, after the proper angle is obtained, (the screws being tightened,) the segments of circles can be worked round a centre with greater accuracy, than could be by tracing over patterns which I believe is the common method; while the alteration of my machinery, for such purpose, would scarcely occupy a minute of time; an object which is of no small importance for the dispatch of business. 3d, The loss of time in centring the work, occasioned by the necessity of removing it from one chuck to another, to receive the different ornaments, (an evil severely felt by turners,) is obviated by my improvement; as also the great difficulty, so often experienced in getting the *face* of the work to run true again, after taking it from one chuck to another; from their liability to get out of truth by the wearing of the screws in fixing them to, and removing them from, the spindle of the lathe; in which case every effort at fine-finishing would be inevitably defeated.

"To apply my apparatus for cycloidal turning, the addition of a rod is required to connect the cutter-frame with the universal chuck, after it is screwed on the spindle of the lathe; but which, on account of its connexion, (being a bad draughtsman,) I am unable to send. The following description will, I hope make its construction appear sufficiently intelligible.

"The edge of the plate of the universal chuck, (the machine on which the work to be turned and ornamented is fixed, and which is a common appendage to all lathes,) I have divided into 144 equal parts, which form a wheel; and upon the face of the left-hand head of the lathe is fixed a plate, and a screw

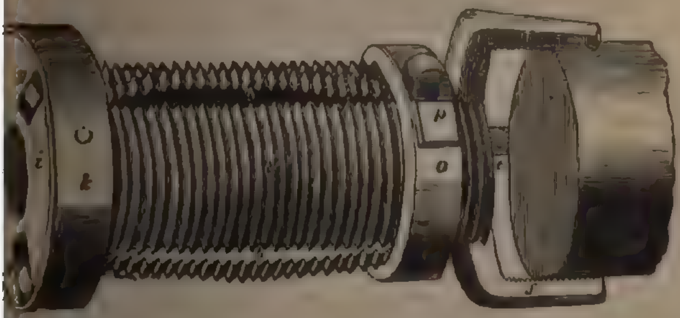
ling one on the side of the rest, through which the axis of the rod connect-the chuck and cutter-frame revolves. Now if upon the rod is fixed a wheel lve teeth, working on the wheel formed by the edge of the universal chuck; if upon the other end of the rod is fixed a wheel of the same size and as those which work the cutter-frame, and to work in one of those ls; then it must be obvious, that, by the chuck revolving once, the wheel of would make twelve revolutions, which number would be given to the -frame, thereby tracing an accurate circle of twelve cycloids. Again, nging the wheel of twelve to another of proper proportions of 144, a er of cycloids would be described equal to that proportion. Then, by the connecting-rod out of gear, and moving the universal chuck any r of teeth forward or backward, the cycloids would beautifully intersect ther.

may, perhaps, be unnecessary to add, that this, and the eccentric appa-must be worked by the hand-motion of the cutter-frame." (In the tle page are given two specimens of wood-blocks, cut by Mr. Wightman than four hours.)

To change it into a drilling frame, all that is required, consists in throwing wheels out of gear, and passing a string over the groove in the cutter-to work on a pulley P, which is fixed on the same arbor as the pulley n double-stringing a lathe. Then pass a string, (which should be kept for urpose,) over the last-mentioned pulley, and under the large or fly-wheel lathe; and after the drill has been fixed in the socket of the cutter-frame, djusted to run true, or central, the machine will be ready for work. Now be clear that, by working the treadle of the lathe, as in turning, a rotary n would be given to the cutter-frame; and after the tool has been ad-d to the work, then, by moving the large or right angle slide of the rest, ght line would be drilled, of a length in proportion to the movement of lide. Then change the division of the plate on the small wheel of the and if the first line was cut *from* the centre, then cut the next *to* the , and so on till the whole is completed, when a beautiful circle of straight would be cut from a centre."

very ingenious expanding chuck was invented by Mr. Lewis Gompertz. 1 and 2 represent two perspective views of the chuck; the first, as employed asp a piece of wood of large dimensions; *Fig.* 2. is an opposite view

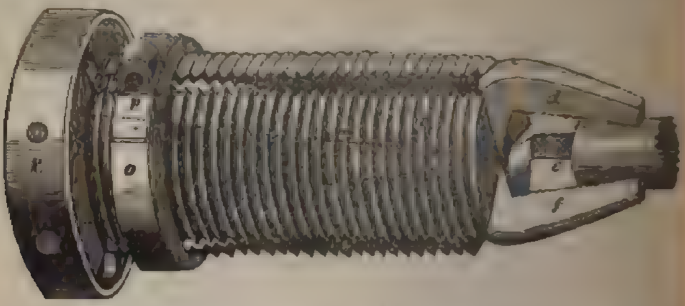
Fig. 1.



the jaws collapsed, to bite a smaller object. *Fig.* 3 shows one of the or jaws separately. The same letters in each figure refer to the same The body of the chuck *a*, is cylindrical, and made of hard wood, with a thread cut on its periphery. Three longitudinal rectangular grooves *b b*, two of which are seen,) are then made throughout its length, slantingly, as

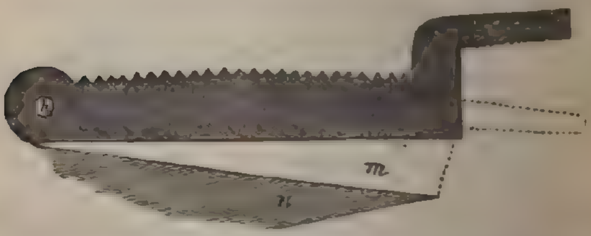
shown by the dotted lines *c c*, *Fig.* 2. The three clamps, *d e f*, one of which is shown entire by *Fig.* 2, are then fixed in these grooves by their jointed ends *g*

Fig. 2.



by means of a pin through their centres *h*, which pass through the solid body of the chuck *i*, and are rivetted to *k*, the metallic hoop of the same. The clamps thus fixed have a range of motion in the grooves, as represented more clearly by *Fig.* 2; the shaded part *l* shows the clamp in the position, when employed as seen in *Fig.* 1; the same in dotted lines *m*, as when employed in *Fig.* 3.

Fig. 3.



and the angular piece *n* represents that portion of a triangular pyramid which is formed in the centre of the cylinder *a*, by the slanting cuts before-mentioned. The clamps *d e f* are made strong, steeled, and hardened at the jaws; their external edges (curved as represented) are filed into grooves or notches, to correspond with the screw-thread on the hard wood cylinder *a*; the metallic ring or circular nut *o*, which is, of course, cut with a screw to fit both the former can therefore be wound over any part of the cylinder, and by that means screws down the clamps firmly to the object they grasp. When the ring is situated as in *Fig.* 1. the jaws are open to receive a large piece; and when moved nearer towards the back, the ring operates to press down the clamps, owing to the curvature of their serrated backs. The projection *p*, on the ring *o*, is for the convenience of applying any thing to it, to move it round forcibly, and a hole is made through it, for the insertion of a wire. The jaws of the clamps should be notched like those of a vice, to obtain a secure hold of the objects placed between them; *r* is the screw, by which the chuck is fixed to the lathe.

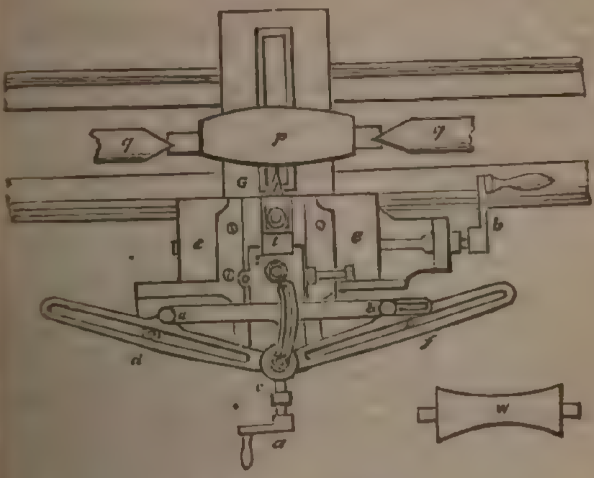
We shall close the present article by the description of a beautiful invention by Mr. John Anderson, a member of the London Mechanics' Institution, to whom was awarded, in 1830, the annual prize, "for the best machine, or any

-ment of a machine;" and of whom Dr. Birkbeck (in a public address on -distribution of the prizes,) elegantly and justly observed, that he had "ele- -d himself in society, by becoming its benefactor;" that, "though now a work- -millwright, Mr. Anderson had evinced a genius that pointed him out for a -guished engineer—probably a Smeaton or a Watt; neither of whom, at his -possessed so much knowledge of algebra, or of geometry, and neither of -had *then* given such decided proofs of genius."

-fter the Doctor had explained the construction and use of the instrument, -h was an improved slide-rest for lathes, Mr. Anderson gave a practical -ration of its utility by turning a convex and a concave roller, which were -leted with great expedition, and fitted each other with mathematical -ness. In this improved slide-rest the object proposed, was to turn the -es of the bodies circular in the longitudinal direction . the curved surface -h direction being either convex or concave to the axis of rotation. And -s more especially intended to apply when the degree of curvature required -ery small, or, which is the same thing, when the radius of the required -s was very great, as, by the present mode of turning, the greatest difficulty -nd in such cases. The improved rest is also found to be equally appli- -to the turning of bodies in the form of lenses, whether convex or concave; -n each of these cases the facility of operation, and accuracy of perform- -, is equal to that of the common slide-rest in turning straight or flat -es.

-e principle of the improvem n t or circle-turning appendage depends upon -eometrical propositions: 1st, that all angles in the same segment of a -are equal; and 2d, that a straight line of any length, being made to move -s parallel to itself with one end touching a circle, the other end will -be a circle equal in every respect to the first.

-e in the improved slide-rest, shown in the annexed figure, the triangle *d c f*



-de to slide against the fixed pins at *d* and *f*: whence the vertex *c* will -be a portion of a circle greater or less in diameter, according as the angle -is made more or less obtuse; and further, the centre of the circle thus -bed, will be on the one side or the other of a straight line joining *d f*, -ding as the vertex *c* of the triangle is on the opposite side.

-e guiding triangle *d c f* consists of three pieces; viz. of two sides *d c*, -*f*, with a slit or opening in each for the pins *d* and *f* to slide in; and -are movable round a centre at *c*, by which means they can be made to

Tasseart, that he had noticed a substance resembling ultramarine, found in a furnace used in the manufacture of soda. The following by which we are told (in the *Annales de Chimie*, xxxvii. p. 109,) may be infallibly prepared.

quartz is to be fused with four times its weight of carbonate of is dissolved in water, and then precipitated by muriatic acid: thus silica will be formed. A hydrate of alumina is now to be prepared, ing alum by ammonia. These two earths are to be carefully washed water; the proportion of dry earth in each is then to be ascertained, small quantity and weighing it. The hydrate of silica used by M. ained 56 per cent., and the hydrate of alumina 3.24 per cent.

ydrate of silica is then to be dissolved in a hot solution of caustic ll take up, and the quantity determined; then such proportion is contains 72 parts of an hydrous silica, and a quantity of the hy-ina, equivalent to 70 parts of dry alumina added to it, and the ated together, being continually stirred until it becomes a damp

nation of silica, alumina, and soda, is the basis of ultramarine, and oloured by a sulphuret of sodium in the following manner. A mix-rts of sulphur with one part of an hydrous carbonate of soda, is to Hessian crucible, covered up, and then gradually raised to a red is well fused; then the mixture is to be thrown, in very small a time, into the midst of the fused mass. As soon as the effer-sioned by the water in one portion has ceased, another portion is Having retained the crucible at a moderate heat for an hour, it is from the fire, and allowed to cool. It now contains ultramarine, xcess of sulphuret: the latter may be separated by water. If sul-cess, a moderate heat will dissipate it. If all the parts are not red, a selection should be made, and then the substance reduced to

artificial product is equal in brilliancy, clearness, and durability, l ultramarine, for which we paid, a few years ago, as much as n ounce; and it is now so extensively manufactured as to be capa-substituted for cobalt, from motives of economy.

A brown coloured earth, prepared as a pigment. See PAINTING.

LA. A very light portable canopy, of a circular form, framed of of whalebone, or other suitable material covered with silk or cloth, by a central staff over the heads of persons, to defend them from rain, ling of the sun's rays. These well-known convenient machines but little improvement in their construction since their introduction try from the East, where they have been in use from time imme-ch manufacturers have, however, by a series of trifling ameliorations, educe the weight of them considerably; to give them more elegance a more perfect and durable action, considering their slender d the delicate materials of which they are made, than they had tained: and all these ameliorations have been effected, together ion of cost equal to fifty per cent.

s will have noticed, that in umbrella frames of the usual construc-s of the whalebone are connected to the top of the umbrella by g of wire, and that the ends of the stretchers are in like manner sliding-tube, which is evidently a very unmechanical arrangement, p and easy of execution it may be; for the axes upon which these tead of being straight lines, are the arcs of a circle, by which the xcessive and unequal, as to insure the speedy destruction of these s, and an early dismemberment of the whole machine. In old likewise be noticed that the stretchers are connected to the middle bone by pins passing through the latter; the holes for these pins ken the whalebones exceedingly, and the subsequent wear of these their thickness so much, that they are frequently breaking;

and the repairs required, from one cause or another, are the source of much inconvenience in rainy weather.

To obviate these defects, each whalebone in Mr. Caney's patent umbrella is connected to the top by separate straight axes, and in such a manner, that they cannot shift themselves out of their places; the stretchers on the sliding-tube are connected in the same way to the sliding-tubes; and the stretchers are jointed to the whalebones without perforating the latter, as will be understood upon reference to the annexed figures: wherein *Fig.* 1 shows one of the ends *a* of the whalebones, *b* the ferrule on it, with a pin *c* passing through its pointed end. *Fig.* 2 shows a plan of the brass plate,—*d* being a plate to which the

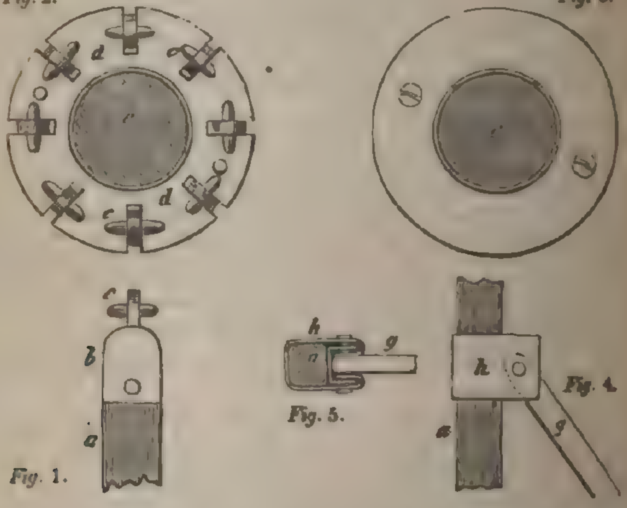


Fig. 2. *Fig.* 3. *Fig.* 1. *Fig.* 5. *Fig.* 4.

whalebones are jointed; *e* is the aperture through which the umbrella stick passes; *c c* denote the pins or axes passing through the joints, and lying imbedded in cavities in the plate, wherein they are confined by the screws of the top brass-plate, shown by *Fig.* 3. The stretchers being jointed to the sliding-tube in the same manner as before mentioned, need no illustration. *Fig.* 4 *a* is one of the eight radiating whalebones; *h* a ferrule made by the doubling of sheet brass around it, to receive the pin or axis of the stretcher *g* without impairing the whalebone; and the manner of doing this is shown in the transverse section in *Fig* 5, in which the same letters of reference indicate similar parts as are already described.

The construction of Mr. Deacon's patent umbrella is in some respects similar to Mr. Caney's. The ends of the ribs in the former have dovetailed caps, these dovetails entering recesses or notches in a cap, wherein they are confined by a plate, which is screwed down upon the whole. Instead of solid sticks, Mr. Deacon makes them of metal, hollow, and covers them with cloth varnished over, or with a coating of papier mache, impressed with ornamental designs. These coverings to the metal are intended to prevent the unpleasant and destructive effects of oxidation of the metal.

A patent was also recently taken out by Mr. J. G. Hancock, of Birmingham, for making light elastic rods for umbrellas, whips, &c., in the following manner: Willow rods of a suitable length have the pith contained in them bored out and in its place are put metallic wires or rods. The wooden exteriors are then reduced, by planes or other suitable tools, to the required shape; afterwards, they

are coloured and varnished, to give them the appearance of whalebone. One end of the rods is capped with metal tips, the other end has the wires extending a little beyond the wooden cases, which are flattened and drilled to receive the wires that fasten them to the handles, and forms the joint on which they turn. Numerous other patents have been taken out for improvements in umbrellas, chiefly by the Birmingham manufacturers, for the metallic portion of the apparatus, termed the "furniture," and the extremely low price at which it is manufactured, is a matter of astonishment to those who are unacquainted with the facilities of the workshops.

URANIUM. A metal discovered by Klaproth in 1789, in the mineral called *pech blende*. In this, it is in the state of sulphuret. But it likewise occurs as an oxide in the green mica, or uranglimmer, and in the uranochre. In obtaining it from pech blende, the mineral is reduced to a fine powder, and digested in a nitric acid till every thing soluble is taken up. The solution is then rendered as neutral as possible by evaporation, and a current of sulphuretted hydrogen gas passed through it as long as any precipitate continues to fall. The liquid is filtered and heated, to drive off all traces of sulphuretted hydrogen. It is now precipitated by caustic ammonia; and the precipitate, after being well washed, is digested, while still moist, in a rather strong solution of carbonate of ammonia. A fine lemon-coloured liquid is obtained, which being set aside for a few days, deposits an abundance of fine yellow crystals, in rectangular prisms. These crystals being exposed to a red heat, give out water, carbonate of ammonia, and oxygen gas, and leave a black oxide of uranium, which is easily reduced to the metallic state, by passing a current of hydrogen gas over it, placed in a glass tube, and heated by a spirit-lamp. The metal presents a liver-brown colour, and remains in the state of powder, being incapable, according to some authors, of reduction by any heat that can be applied to it. Dr. Ure, however, informs us that 50 grains, after being ignited, were formed into a ball with wax, and exposed in a well closed charcoal crucible to the most vehement heat of a porcelain furnace, the intensity of which gave 170° on Wedgewood's pyrometer. Thus a metallic button was obtained, weighing 28 grains, of a dark grey colour, hard, firmly cohering, finely grained, of very minute pores, and externally glittering: specific gravity, 8.1. A sulphuret of uranium has been formed, which has a black colour, and, when rubbed, a metallic lustre. Its capacity for forming alloys with other metals remains uninvestigated, in consequence of the scarcity of the metal. The oxides of uranium are used in painting upon porcelain yielding a fine orange colour in the enamelling fire, and a black one in that in which the porcelain itself is baked.

URN. A vessel of a vase or pitcher-like form. The vessels employed to keep water boiling at the tea-table, have thus been called tea-urns, notwithstanding every possible deviation has been subsequently made in their figure. The construction of ordinary tea-urns are too well known to our readers to require elucidation, but we shall here present to their notice one that possesses some claims to novelty, which must, however, be regarded rather as an elegant article of luxury, than one of great utility. This is Sharp's patent tea-urn, combined with a tea-pot in one vessel.

The engraving on page 832 represents a vertical section: *a* is the ordinary urn or vessel that holds the water; *b* the red-hot heater in its case; below the bottom of the case, the tube is prolonged so as to form a small chamber underneath, which is perforated at its sides with minute holes, through which the water passes by a tube *d* into the vessel *f*, when the valve (shown in the figure as closed) is opened by turning the lever *e*. The infusion is represented by the unbroken straight lines at *f*, and the tea leaves by dark looking masses, lie upon a grating or perforated bottom, through which passes clear to the lowest chamber *g*, from whence it is drawn off, as wanted, by a tube and cock, seen only in section at *h*. The plain water is drawn from the vessel *a* by means of the long tube *k* (which passes directly through the tea chamber) and a cock at *l*, also viewed only in section. It should now be observed that both the cocks *h* and *l* are inclosed in one tube or case, but they are united externally into

one, but provided with two lever handles, the handle on the left applying to the tea-cock, and that on the right to the water-cock.

It is a common remark, that tea made from the water in an urn is never so good as that supplied directly from a tea-kettle, on account of the difficulty of keeping the water boiling in the urn. To remedy this defect, we

submit to tea-urn makers a different arrangement. Let the vessel be placed above the water vessel, (not in it) and the metallic supports which connect the two vessels would conduct sufficient heat to keep the infusion at a proper temperature. Underneath the water-vessel burn a small spirit-lamp, instead of inserting the red-hot heater, which is a very inconvenient, and by no means an economical mode of heating.

V.

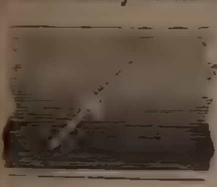
VACUUM. A space devoid of all matter. See AIR-PUMP, STEAM-ENGINE and GAS-ENGINE.

VALVE. A cover or stop to an aperture, to control or direct the course of fluids. They are usually contrived so as to be readily opened by a small force acting on one side, and to be perfectly closed by a force when acting on the opposite side; and thus either admit the entrance of a fluid into a tube or vessel and prevent its return; or else permit the fluid to escape, and prevent its re-entrance.

Valves are members of the utmost importance to steam-engines, pumps, and a variety of pneumatic, hydraulic, and hydrostatic machinery; and they are constructed in a great variety of forms, to adapt them to their several uses. Cocks employed for drawing off liquids are strictly valves; but this class of valves we have described under their usual distinctive name. (See COCKS.) Numerous valves have been described in different parts of this work, under

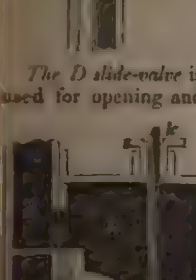
the above-mentioned subjects, we shall therefore notice in this place several varieties which have not been elsewhere specified.

Throttle-valves usually consist of a thin disc, or circular plate of metal which entirely crosses the area of the steam-pipe, when closed, being supported by an axis or spindle, which passes diametrically through, or across it, and into the sides of the pipe. This spindle is either operated upon by the governor of the engine, or by hand, setting it open to such an extent as to intercept more or less of the steam in its passage to the engine.

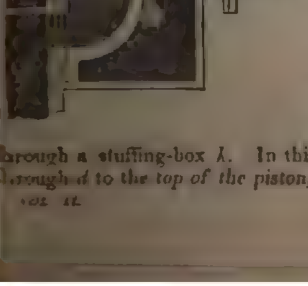


Field's Regulating Valve, is a contrivance introduced by Mr. Joshua Field, of the firm of Maudslay and Co.; the object of which is to regulate the supply of the steam in a superior manner to the throttle-valve last described. "It consists," says Mr. Tredgold, "of a valve, placed in the situation usually assigned to the throttle-valve, that is, near to the place where the steam is admitted to the cylinder. This valve is to be opened at once, at the commencement of the stroke, so as to afford full passage to the steam, and shut at once, after a certain part of the stroke is made, that the rest of it may be completed by the power of the steam." Thus, by causing the valve to be shut sooner or later during the stroke, the power of the engine may be regulated.

One of the earliest and simplest contrivances for completely reversing the direction or course of steam, water, or other fluids, is the four-way cock. It was adopted by Leupold, upwards of a hundred years ago, and has been subsequently applied in very numerous instances; particularly by Mr Trevithick, in his locomotive high-pressure engines, and by most of the locomotionists of the present day. The annexed cut exhibits a vertical section of a four-way cock, considered as applied to a steam-engine: at *a* is represented the communication with the steam-pipe from the boiler; *b*, the passage to the upper side of the piston; *c*, the passage to the lower side of the piston; and *d*, the passage to the condenser. In the position represented, the steam is entering the upper part of the cylinder, and the lower part is open to the condenser; but if the plug, or central movable portion of the cock be moved one quarter of a revolution in either direction, then the steam is opened to the lower part of the cylinder, and the upper part is open to the condenser.

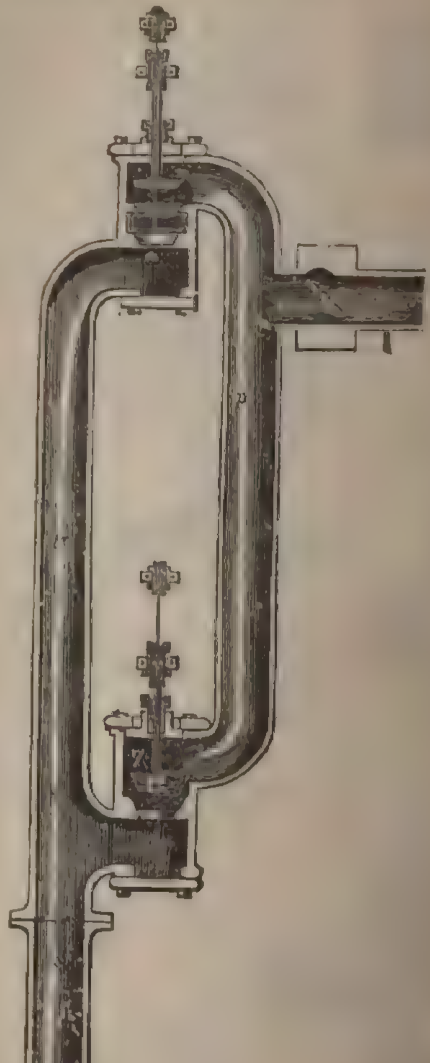


The D slide-valve is another invention of great simplicity, and has been much used for opening and changing the communications with the steam cylinder. In the annexed vertical section, *a* is the steam-box, into which steam is admitted by the passage *b*. This box is bolted to a pipe, divided into three compartments; viz. *d*, a passage leading to the upper side of the piston; *e*, a similar passage to the under side of the piston; and *f*, a passage to the condenser. The apertures of this passage are faced with brass, and the space between each opening it is essentially necessary should not be less than each opening; *g* is a block of metal with a cross cast into it, equal in length to two of the apertures and the space between them; the block is generally faced with brass, and grooved upon the pipe, so as to slide over it steam-tight; it is moved by a rod, which passes through a stuffing-box *k*. In this position of the slide, the steam would pass through *d* to the top of the piston, whilst the steam beneath the piston would



... tion-passage *f*. On raising the slide, *d* becom... ..., and *e* to the steam.

... four-way cock, however, equally possess a great ... the steam that fills the passages of the movable portion ...



... Watt, Hornblower, Murdoch, and other steam mechanicians, ... modifications of the D and other valves, by which the waste of steam was ... ...ated. The invention of Mr. Murray in 1799, for the same purpose, ...

high in our estimation, being attended with less friction than the others; accordingly give it insertion in this place.

in the foregoing figure, is the pipe conveying steam from the boiler, and vering it into the descending pipe *p*, which terminates in the valve *q*, ning to the lower part of the cylinder, by the side opening, marked as a aded parallelogram, while the valve *r* opens a similar communicatjon with the er part of the cylinder; so that, by the successive opening and shutting of *q* *r*, steam is admitted above and below the piston. *s* is the lower end of the ction-pipe, joining on to the condenser, and this pipe opens first to the lower of the cylinder by the valve *t*, and leads also by a perpendicular continu- n of the same pipe *v*, to a valve *u*, by which a connexion is formed with upper part of the cylinder. The two apertures into the cylinder, called les, are therefore common both to the admission of steam and the forma- of a vacuum, which is regulated simply by the working of the valves. For he figure now stands, *r* is the only open valve in the steam-pipe; consequently m would enter above the piston to depress it, while a vacuum would exist be- it, on account of the valve *t* being open to the condenser. As soon as the on reaches the bottom of the cylinder, the valves *r* and *t* must be shut, and d *q* opened; when the steam, being no longer able to get through *r*, would down the pipe *p*, and enter the lower part of the cylinder through *q*. Mean- *u* being opened to the condenser by the pipe *v*, would cause the necessary uum above the piston to permit its ascent, which being completed, the valves t be again put into the position shown in the figure, to produce its descent, so on. It will be sufficient to state that these valves are operated upon either levers, passing in a steam-tight manner through the side pipes, or that some- s the spindles of the valves are made to act one through the other, in ing, as in the present instance, when they are worked by external applica-

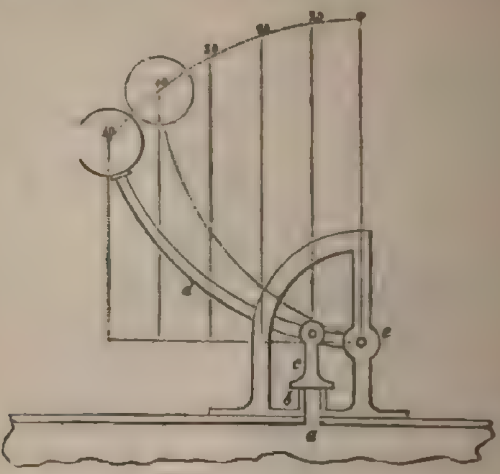
y this most ingenious contrivance no waste of steam arises, excepting in the ll aperture between the valves; and the friction is obviously much less than ther slides, cocks, or perhaps any other kind of valve; the only resistance heir motion being the pressure upon the upper side by the steam, when in seats. Their cost, compared to slide-valves, is much greater; but as they not liable to material wear, and work with great accuracy, the extra ex e does not prevent their very general adoption in large engines.

aving thus briefly noticed a very important class of valves, we proceed to ribe another kind, which have even stronger claims upon our attention, as be immediately acknowledged by naming them,

fety-valves; these are well-fitted covers or stops to apertures made in the r part of a boiler, and loaded to such a degree only as the steam will over- when it exceeds the required pressure. The contrivance, in nearly its usual (the steelyard,) was invented by Dr. Papin, in 1684, as an appendage to his ratus for dissolving bones by steam at high pressure; but the first applica- of it to the steam-engine was by Savery. It received some improvement eighton in 1718, since whose time the same form continues to be used, as be recognised in numerous steam apparatuses in various parts of this work. Tredgold, in his able work on the steam-engine, observes, that it would be at improvement upon safety-valves, if they could be so constructed as to be ved of a part of their load, when raised from their seat. With the view of ing this object in the simplest possible way, we suggested many years ago, *Register of Arts, &c. for January*, 1829) the employment of a bent lever, in- of the straight one in common use, the action of which will be understood ference to the subjoined diagram, wherein is also represented some other fications of the safety-valve, which it is presumed are worthy the consider- of the practical man.

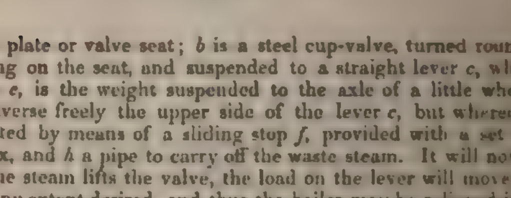
epresents an aperture in the upper part of a boiler; over this aperture is a short tube *b*, turned true at the top with a round edge, so that a steel *c*, flat and smooth on its under side, may touch at every part; this steel is suspended by a joint, to a curved lever *d*, whose fulcrum is at *e*, and is loaded at the other end with a weight of 10 pounds. Now, as the

lever has a power of five, (as shown by the five equal dotted spaces,) the plate *c* is pressed down upon the edge of *b*, with a force of 50 pounds; but when the lever and weight are raised, by the pressure of the steam, into the position shown by the dots, the force acting against the steam is reduced to 40 pounds;



and, in proportion to the force of the rush of the steam, by which the lever would be raised higher and higher, would the resistance be reduced to 30, 20, &c. as marked. This valve might be enclosed as usual, in a box, with a pipe to conduct off the waste steam.

The subjoined diagram is explanatory of another mode of producing a similar result, but by different means; *a* is the aperture in the boiler, on which is fixed



a gun-metal plate or valve seat; *b* is a steel cup-valve, turned rounding at the edges, resting on the seat, and suspended to a straight lever *c*, whose fulcrum is at *d*. At *e*, is the weight suspended to the axle of a little wheel, which is made to traverse freely the upper side of the lever *c*, but whereon its range may be limited by means of a sliding stop *f*, provided with a set screw; *g* is the valve box, and *h* a pipe to carry off the waste steam. It will now be obvious that when the steam lifts the valve, the load on the lever will move towards the fulcrum to any extent desired, and thus the boiler may be relieved in proportion to the exigency of the case. It scarcely need be remarked, that our reason for making the valves with edges pressing upon flat surfaces, was to prevent the possibility of their sticking in their seats, which, with the conical plug valves is a common occurrence, and one that has been productive of serious accidents.

The safety-valves employed by Woolf, are calculated to prevent adhesion of

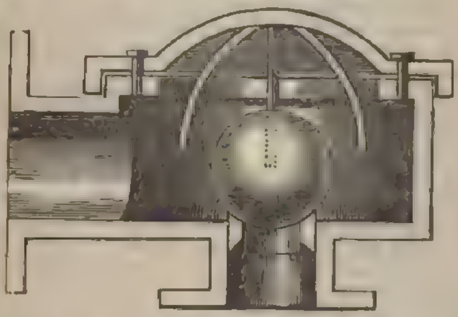
their seats, and are of great simplicity; their form is represented in the margin, *Fig.* 1 being a plan, and *Fig.* 2 a vertical section. The shape may be considered at first as a solid cylinder with a circular plate at top; three large longitudinal grooves, as shown at *a a a*, reduce the cylinder to the figure represented. The plug thus made, fits easily into the aperture of the boiler, and the steam which fills the grooves, pressing against the under surface of the head, raises the plug and escapes. The plug is loaded either by a weight, suspended to it inside the boiler, by weights laid directly upon the top, or by the agency of a loaded lever.

Fig. 1.

Fig. 2.

In a letter to the editor of the *Leeds Mercury*, Mr. Benjamin Hicks, of the steam-engine manufactory at Bolton, in Lancashire, says, "I am induced, in order to prevent the accidents occasioned by the bursting of steam-boilers, which are of such frequent occurrence, and generally so dreadful in their consequences, to send to you the drawing and description of a self-acting safety-valve, of my invention, (or rather application to a new purpose; a similar valve having been used as a clack for a pump, upwards of a hundred years ago.) You will readily perceive, from the several advantages it possesses, that wherever its adoption shall take place, it would scarcely be possible for an accident of this nature to arise.

"The opening in the lower part of the box, which is fixed on the boiler-top, or, if more convenient, on any part of a pipe having a free communication with it, requires to be of such a size, as to allow a free discharge of all the steam the boiler is capable of generating. This opening is covered with a spherical valve,

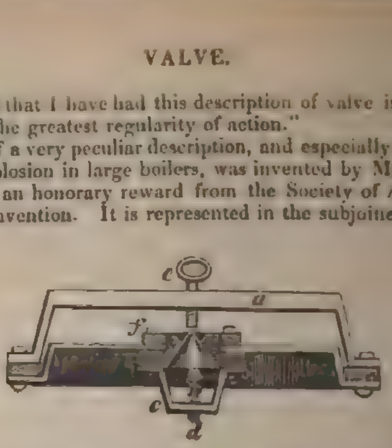


(the outer part of which is brass, filled with lead.) of such a size, and consequently weight, as to press with as many pounds per square inch, as it is intended the strength of the steam, at a *maximum*, in the boiler, should ever be raised to; the obvious effect of which will be (*owing to its being perfectly free from friction*,) that, at the very instant the steam arrives at that degree of pressure, the ball will be raised, and a discharge instantly take place. The projections are merely to prevent the ball at any time from falling off its seat.

"From the nature of its construction, requiring no packing or attention, it can be entirely secured from the interference of careless attendants, and a pipe may be attached to the branch of the box, and continued into the chimney, or any other convenient place of discharge. I should not recommend this valve to be used as a substitute for the ordinary safety-valve, (improperly so called,) but in all cases in addition, and so loaded, as only to be brought into action at a very trifling additional pressure above that, to which the other valve is weighted. This valve would be found of the greatest advantage, in preventing the boiling over of the feed-pipes of boilers, when the rooms over them are used as drying-stoves in print-works, bleach

"I ought to state that I have had this description of valve in use for upwards of four years, with the greatest regularity of action."

Another valve, of a very peculiar description, and especially adapted to afford security against explosion in large boilers, was invented by Mr. Sockl, of Lambeth, who received an honorary reward from the Society of Arts, for the communication of the invention. It is represented in the subjoined cut.



Instead of the lid which covers the main hole, a copper plate or dish is to be substituted, as shown in the darkened part of above figure: this copper dish is surrounded by a ring of the same metal, by which the plate is firmly screwed down upon the rim of the main hole. In the middle of the plate is fixed the valve, of which *f* is the collar, made of iron or brass; *d* the plug, which is ground air-tight into the collar, and is kept in its place by the spiral spring which surrounds its stem, and the stay *c*: over the whole is fixed a cross-piece *a*, which is firmly screwed down upon the ring that secures the dish. In the cross-piece, works the regulating screw *e*, which may be screwed down upon the head of the plug.

The operation of the valve is easy to understand. The copper dish is only about one-fourth the thickness of the other parts of the boiler, and will not therefore afford the same resistance to the steam: when this, therefore, gets beyond the ordinary pressure, it will cause the dish to become somewhat convex, and will thus leave a clear space between the collar *f*, and the conical plug *d*, for the steam to escape; as soon as the power diminishes, the plate will, by its elasticity, return to its former place, and by closing down upon the plug, prevent any further escape of steam.

The object of this valve is not so much to regulate the working pressure of the steam, as to act in aid of the common valve, by affording an additional aperture, in case the steam should acquire a dangerous degree of force. It differs from the plug-valves in common use, in this circumstance, namely, that in the latter, the plug rises out of its socket, in order to allow of a vent for the steam, whereas in Mr. Sockl's, the socket rises away from the plug. The chief advantage resulting from this is, that if any adhesion should have taken place between the plug and the socket, it is more likely to be overcome, on account of the great surface of the socket, with its attached copper plate, which is exposed to the action of the steam.

A substitute for the common ball-cock, used for regulating the height of liquids in reservoirs, has been introduced by Mr. Darnall, of Pentonville, the construction of which is exhibited in the annexed section: *a* is the supply pipe, *b* the valve, (shut,) *c* a float connected to the valve by an upright spindle. As the water is drawn off, the float descends from its seat into the chamber beneath, allowing the water to pour through the apertures shown, into the reservoir; the float, as it rises again with the water in the reservoir, closes the valve, and shuts off the supply of water, when it has attained its proper elevation.

We shall here close the article upon valves, referring the reader to the machinery before mentioned for further elucidations, and likewise to the article Water-Closet, which mainly consists of valves of a very ingenious construction.

VANADIUM. A newly discovered metal by M. Sefstrom. It has been briefly described in a letter from M. Berzelius to M. Dulong, from which the following is an extract :—" M. Sefstrom, director of the School of Mines at Fahlun, whilst engaged in examining a variety of iron, remarkable for its extreme softness, observed the presence of a substance, the properties of which differed from all other known bodies, but its quantity was so small as would have rendered it tedious and expensive to collect sufficient for a correct examination of its properties. This iron was from the mine of Taberg, in Smoland; the ore merely contained sources of the substance. Finding that the pig iron contained far more of this principle than the wrought iron, M. Sefstrom thought that the scoriæ formed during the conversion of the pig iron into wrought metal might be a more abundant source; a conjecture confirmed by experience; so that sufficient having been procured, he went to M. Berzelius to complete its examination."

Vanadium combines with oxygen to form an oxide and an acid. The acid is red, pulverent, fusible, and on solidifying becomes crystalline. It is slightly soluble in water, reddens litmus, and forms yellow neutral salts, and orange bisalts. Its combinations with acids or bases have the singular property of suddenly losing their colour; they resume it only on becoming solid again, and being then re-dissolved, preserve their colour. Hydrogen at a white heat, reduces vanadic acid, leaving a coherent mass, having a feeble metallic lustre, and being a good conductor of electricity, but it is not certain that the reduction is complete. The oxide of vanadium is brown, or nearly black, and dissolves readily in acids. The salts are of a deep brown colour, but by the addition of a little nitric acid, effervesce and become of a fine blue colour. The oxide and acid of this metal together produce other combinations, green, yellow, and red, all soluble in water.

When the oxide of vanadium is produced in the humid way, it is soluble both in water and alkalies. The presence of a salt renders it insoluble, and upon this effect may be founded a process for its preparation. Before the blowpipe, vanadium colours fluxes of a fine green, in this respect resembling chrome.

VAPOUR, from the circumstances of its formation, may be considered to consist of extremely minute vesicles of water or other fluid, inflated with air. See Steam, Alcohol, &c.

VAPOUR-BATH. A closet or room, in which a person exposes his body to the action of vapour introduced by a pipe from a boiler. See Bath.

VARNISH. A solution of resinous matter, which, laid upon the surface of solid bodies, becomes hard, glossy, impervious to moisture, and gives beauty and durability to them. Under the several heads of Lac, Copal, Mastic, Caoutchouc, and other resins, we have described the process of preparing varnishes from them; we shall therefore in this place take a general, but concise view of the subject. The solvents are either expressed or essential oils, as also alcohol. For a lac-varnish of the first kind, the common painter's varnish is to be united by gently boiling it with some more mastich or colophony, and then diluted again with a little more oil of turpentine. The latter addition promotes both the glossy appearance and drying of the varnish; of this sort is also amber varnish. To make this varnish, half a pound of amber is kept over a gentle fire in a covered iron pot, in the lid of which there is a small hole, till it is observed to become soft, and to be melted together into one mass. As soon as this is perceived, the vessel is taken from off the fire, and suffered to cool a little; when a pound of good painter's varnish is added to it, and the whole suffered to boil up again over the fire, keeping it continually stirring. After this it is again removed from the fire; and when it is become somewhat cool, a pound of oil of turpentine is to be gradually mixed with it. Should the varnish when it is cool happen to be yet too thick, it may be attenuated with more oil of turpentine. This varnish has always a dark brown colour, because the amber is previously half burned in this operation; but if it be required of a bright colour, amber powder must be dissolved in transparent painter's varnish, in Papin's machine, by a gentle fire.

"I [illegible] varnishes with ethereal oils alone, of four [illegible] of turpentine. For making this,

Anoth[illegible] by a very gentle digesting heat, securi[illegible] used for the modern transparencies both, wh[illegible] and for other purposes. These are munica[illegible], and afterwards coated with this varnish [illegible] be transparent. Sometimes fine thin [illegible] purpose; but it requires to be primed with [illegible] is laid on. Copal may also be dissolved [illegible] to Mr. Sheldrake, by adding it in powder [illegible], and stirring till the whole is fused. See

[illegible] of thin turpentine is obtained for aerostatic [illegible] part of elastic-gum, or caoutchouc, cut into [illegible] of rectified oil of turpentine. Previously to use [illegible] be passed through a linen cloth, in order that the [illegible]ound. See CAOUTCHOUC.

[illegible] consists in the spirit-varnish. The most solid [illegible] varnishes; but a varnish must never be expected [illegible] naturally is of which it is made. But the most solid [illegible] brittle varnishes; therefore something of a softer [illegible] mixed with them, whereby this brittleness is diminished [illegible] gum-elemi, turpentine, or balsam of copaiva are [illegible]tions.

[illegible] polish" is effected by a spirit-varnish, treated in a [illegible] mode of preparing and using it may be relied upon [illegible] from that very accurate French work, the *Diction*[illegible] The varnish is composed of

[illegible]	. . . .	14 oz. & 2 drachms.
[illegible] drops	. . . . . .	7 ,, 1 ,,
[illegible] yellower the better)	.	14 ,, 2 ,,
[illegible]95° spe. gra.	. . . .	3 quarts & 1 pint

[illegible] are to be pounded, and their solution effected by continued [illegible] of heat. When the woods to be varnished are very [illegible] 1 drachm of Venice turpentine. In order the better to [illegible] cause them to present a greater surface to the action of [illegible] should be mixed with an equal weight of ground glass, the [illegible] of the resin from forming clots, the solution is thus [illegible] time. Before applying the varnish, the wood should be [illegible] linseed oil; it must then be rubbed with old flannel, [illegible] excess of oil; blotting paper may be used for the same [illegible] sifted saw-dust. Afterwards the varnish should be applied, [illegible] a piece of old soft coarse linen cloth, many times folded, [illegible], and rubbing it softly on the wood, turning the linen from [illegible] appears nearly dry. The linen should be saturated afresh [illegible] the rubbing be continued in the same manner, until the pores [illegible] completely filled. Care should be taken not to make the linen [illegible] too hard, especially at the beginning of the operation. When [illegible] or becomes *tacky*, a very small drop of olive oil is to be ap[illegible] of a finger, uniformly all over the cushion. The finishing [illegible] a little pure alcohol upon a piece of clean linen, which [illegible] the varnished wood; and as the linen and the varnish dry, [illegible] more briskly, until it takes a beautiful polish like a looking-[illegible] three coatings of varnish are sufficient for woods not very

[illegible] varnish may be obtained, by dissolving eight ounces of [illegible] and two ounces of Venice turpentine in thirty-two ounces of [illegible] heat. Five ounces of shell-lac and one of turpentine, dis[illegible]-two ounces of alcohol by a very gentle heat, give a harder

varnish, but of a reddish cast. To these the solution of copal is undoubtedly preferable in many respects. This is effected by triturating an ounce of powder of gum-copal, which has been well dried by a gentle heat, with a drachm of camphor, and, while these are mixing together, adding by degrees four ounces of the strongest alcohol, without any digestion. Between this and the gold varnish there is only this difference, that some substances that communicate a yellow tinge are to be added to the latter.

Oil-varnishes are commonly mixed immediately with the colours, but lac or lacquer-varnishes are laid on by themselves upon a burnished coloured ground; when they are intended to be laid upon naked wood, a ground should be first given them of strong size, either alone, or with some earthy colour mixed up with it by levigation. The gold lacquer is simply rubbed over brass, tin, or silver, to give them a gold colour. (See LACQUER.) The coloured resins or gums, such as gamboge, dragon's-blood, &c., are used to colour varnishes.

The essential varnishes consist in a solution of resin in oil of turpentine. The varnish being applied, the essential oil flies off, and leaves the resin. This is used only for paintings.

Before a resin is dissolved in a fixed oil, it is necessary to render the oil drying. For this purpose the oil is boiled with metallic oxides, in which operation the mucilage of the oil combines with the metal, while the oil itself unites with the oxygen of the oxide. To accelerate the drying of this varnish, it is necessary to add oil of turpentine. When resins are dissolved in alcohol, the varnish dries very speedily, and is subject to crack; but this fault is corrected by adding a small quantity of turpentine to the mixture, which renders it brighter, and less brittle when dry.

VELVET. A rich kind of silk or cotton cloth. See WEAVING.

VENEERING. The art of fixing, in a firm and durable manner, very thin leaves of a fine or superior wood, over a coarse or inferior wood; so as to give the latter the appearance of a solid mass of the former. The thin leaves are called veneers, and are cut from the logs by fine saws, now usually worked by machinery. See SAWING-MACHINERY.

Inlaid work is effected by veneers cut into suitable pieces, for the purposes. The thickness of veneers is from a tenth to a twelfth part of an inch. When the dimensions of these have been nicely adjusted to the work in hand, they are glued down; and, that the work may be solid, they are put into a press made for the purpose, or are held down by planks and poles, abutting against the beams of the workshop. When the glue is thoroughly dry, the work is taken from the presses, and finished by smoothing-planes, scrapers, fish-skin, &c., and afterwards polished by shave-grass and brushing, waxing, varnishing, &c., according as it may be required.

VENTILATION. The act of renovating the air of chambers, houses, ships, and all kinds of buildings or places. We may exist for several days without food, but we die, if deprived only for a few minutes of air. As air is necessary to life, so is pure air to health. But it appears that this important fact escapes the attention of the greater part of mankind, who are prone to blame the cook or the purveyor for the greater part of their ailments, without reflecting upon the impure air they may have been inspiring at the rate of about two gallons per minute. The oxygen gas, or vital portion of the atmosphere that enters the lungs, is changed at each respiration into carbonic acid gas. This gas, as is well known, is poisonous, if inspired alone, or even if a large proportion of it be mixed with the atmospheric air. But by an admirable provision of the great Author of Nature, this contaminated air is rendered specifically lighter than the pure atmosphere, from the heat it has derived from the lungs, and consequently rises above our heads, during the short pause between our respirations; thus insuring to us always a pure draught of air, unless we prevent it by artificial means.

It is not, however, always owing to a deficiency of oxygen, that the air of rooms or crowded places becomes pernicious to health. A council of health, established by the French government, proved that in an atmosphere which had not lost one-twentieth part of its oxygen, an animal miasmata was diffused in

vapours: that by suspending, in such atmospheres, a glass vessel filled with ice, the vapour diffused in the air becomes condensed on its surface, and the liquid thus obtained by condensation, being collected in another vessel suspended underneath the former, exhales a fetid odour, and speedily undergoes the putrid fermentation, when exposed to a temperature of 79° Fahr.

Certain gaseous and other vapours may be mixed with the air we breathe, without producing any very marked inconvenience; but the effects of a mixture of many other kinds are highly dangerous, and more quick in their action than even those of animal miasmata. A constant renewal of the air is absolutely necessary for its purity; for in all situations, it is suffering either by its vital part being absorbed, or by impure vapours being disengaged and dispersed through it. Ventilation therefore resolves itself into the securing a constant supply of fresh air. Rooms cannot be well ventilated, that have no outlet for the air, and this, from the superior levity of foul air, should be made at the highest point that can be obtained, and so arranged as to diffuse the fresh air that enters over the upper part of the room, and not inconvenience the persons in the room, by descending upon them in a current. There should be a chimney to every room, which on no account should be stopped up with a chimney board, as is often the case in bed-rooms. We have observed also, in many houses, that the top sashes of windows of the upper rooms are made fast; now if these were made to slide downward, instead of the lower sashes upward, increased salubrity, as well as security, (especially in the case of children,) would be obtained. In whatever way fresh air may be made to enter an apartment, it should be, as far as may be practicable, at the part remotest from the fire-place, in order that it may traverse the whole apartment in its passage to the chimney. The most effective species of ventilation is that in which nature is adopted as the guide. The simple action of the sun, no less than the devastating phenomenon of the African tornado, tend to the same result. We have only to change the temperature of the air which surrounds us, and a new portion will rush in from the adjacent and purer parts, to supply its place. From this it is obvious, that a lamp placed in an aperture of the ceiling, in any large and crowded room, will tend to purify the air. This is precisely the case in our large theatres as that at Covent Garden, where the great glass chandelier, with its numerous gas burners, gives out a great quantity of heat, immediately under a large funnel, which passes through the roof, into the open air. The rarified air which thus rushes through the funnel, is constantly succeeded by continuous fresh currents, entering at numerous apertures beneath, to restore the equilibrium of pressure.

Notwithstanding this arrangement is calculated to render the atmosphere of crowded places more fit for respiration, it is productive of a painful and serious inconvenience to those persons who may be situated near to the apertures before-mentioned, where the fresh air enters; they are thus exposed, as it were, to the action of a series of blow-pipes, and the consequences are, colds, asthmas, and rheumatisms, in abundance. To avoid drafts, and yet ventilate thoroughly, has hitherto been found of difficult accomplishment. In "A letter to the Earl of Chichester, on the practicability of rendering those properties of air, which relate to caloric, applicable to new and important purposes, (1823.)" by Mr. John Vallance, of Brighton; that gentleman has proposed a plan for warming and ventilating the Houses of Parliament, which, in *principle*, is admirably designed to obviate the difficulties just mentioned; we shall, therefore, give it a place here in the author's own words; although there are some mechanical difficulties to be overcome, before it can be rendered elegant and convenient; the means of effecting which, will, we trust, be ultimately accomplished.

"There are two principles which operate to alter the state of air, in any room where numbers of people convene. One of them affects it physically, and to a change of density, and is the cause of drafts and influxes of cold air; the other affects its chemically, and to a change of quality, as the medium by which the action of the lungs is rendered efficient to the preservation of life, and renders necessary, and indeed indispensable, the drafts and currents of which the first is the cause. The first of these occurs in every place in which air is heated; the other, only in those places in which it undergoes respiration. Now, it is

f these that falls under our consideration, when investigating the hich drafts take place; and the course of operation of this prin- If heat be communicated to a particle of air, a change takes ect to that particle in the following manner; it becomes expanded n bulk, in some such way as may be conceived, by reference to ractice of holding a flaccid bladder before the fire, to tighten and prior to using it as a football.

nsion it is increased in bulk but not in weight; and in conse- rom among the other particles, and ascends towards the ceiling; y that a bladder, filled with air, would rise through, and swim at e filled with water, were they thrown into the sea together; and, rcumstance which caused this particle to be where it chanced to this supposed heating took place, was its gravity; the moment ltered, and it, in consequence, rendered ter than the surrounding particles, it passes through them towards the ceil- he course of operation of the principle; is this:—The moment this particle of away from what heated it, its place is er, which, undergoing the same change, ke manner, having its place taken by a and this alternation continues all the mmunicated, be the communicator what the human body, a stove, or any other ing.

ffect of air's being heated; its physical and it becomes specifically lighter than

A

ence of its becoming lighter, may be :—If a glass tube were taken, shaped in ith a notch or crevice cut in it at A, or crevice a metallic slide were well ted, so as to cut occasionally off the between the two legs; if into this (when the slide was pushed in, so as communication) poured, in one leg, d in the other water, and then, when (placing the thumb on the top of the he water in it, to keep it in,) the slide uicksilver and water were pulled out to let them press one against very evident that the superior weight of the column of quick- use it to press the column of water upwards against the thumb, the thumb removed, the water would be driven up, and some of the tube; and also, that the water would continue to rise, till the two legs counterbalanced each other. Now, this is an illus- t takes place in any building, whenever the air inside it is hotter thout.

ternal air being heavier than the internal air, the former so the latter, as to press it upwards against the ceiling, in the same he water would be pressed against the thumb; and if a part of ut away, so as to open a means of emission similar to what the thumb permitted; that is, if a ventilation aperture be opened in superior weight of the cold external air will cause it to drive rnal air up through that aperture, till the equilibrium becomes f, owing to the air on the inside being by the respiration, &c., ned in the building, kept constantly warmer and lighter than , this equilibrium is prevented, and the difference between the ternal atmosphere kept permanently up, the consequence then stead of a single and transitory emission, like that of the water here will be a continuous emission of air through the ventilator,

all the while the respirations, &c., of those who are assembled in the building keep up the difference. Now this is what takes place in all public places; and as, owing to the door and windows being, during cold weather, kept shut, the aperture of admission (or channel by which the external air enters the building) is rendered very much smaller than that of emission; to make up for the difference thus caused between the apertures of admission and emission, the cold external air is obliged to make use of all the cracks and crevices that are about either the doors and windows, or elsewhere around the building, and to introduce itself through them with a velocity so much greater than that at which it passes off by the ventilator, as will make up for the difference between the sizes of the cracks and crevices by which it enters, and that of the ventilation aperture.

This is the reason why drafts are experienced from the crevices of doors and windows: the heated and respired air passes off by the ventilator; to make up for what so passes off, fresh air flows into the bottom of the building, and as, when the weather is cold enough to make us shut the doors and windows, ingress by a duct equal to that of egress is prevented, to make up, by the rate at which it enters, for the difference in the sizes of the apertures of admission and emission. the air that finds its way in through cracks and crevices, enters with so great a velocity as to cause the chilling currents we experience.

Instead of suffering ventilation to take place at the pleasure of the air, I restrict and regulate it thus:—I first have the windows of the place nailed down, to prevent them from being ever opened; I then have the joints and crevices, both of these windows and of the room in general, so filled with putty, or so treated with any kind of lute or luting, that will answer the purpose, as shall prevent their becoming channels through which drafts or currents may find their way either into or out of the place. I then have the door-ways arranged thus:—Removing the present doors, the door-way is made six feet wide, by about the same height, and into it is fitted a cylinder (of wood or metal) closed at both ends, and placed upright on one of them, so as to appear somewhat like a cask

built into the wall. Through the side of this cylinder I have two apertures cut, each about four feet wide, by the height of the cylinder inside [illegible] which apertures are opposite, the middle of each being in the line of the centre of the cylinder, so as to leave a way of about four feet wide, right through the middle of it into the place, as shewn above, where the cylinder is represented placed in the wall, with the apertures in it. In the centre of the cylinder, there

is now put (perpendicularly) a shaft, of about three inches diameter and of the length of the cylinder; and having it, and the centres of the top and bottom of the cylinder, so prepared and fitted to each other, that the shaft may easily turn round, or revolve; then there are fixed on it, at right angles to each other, eight arms or radii, four at top, and four at bottom; the bottom four being exactly under the upper ones. To these arms there are fixed four sheets, or pieces of iron plate, of such lengths and widths as will just go into, and fill up, (though without touching,) the space left between the shaft and the side of the cylinder; and these things being so done, that the plates or leaves fixed on the arms may turn easily round, inside the cylinder; and the ends and sides of these leaves being so fitted to each other that, when the leaves are turned round, there may not be a space greater than about the sixteenth of an inch left between them, the arrangements for the door-way are complete; and the cylinder through which the place is entered, has within it four leaves or wings, somewhat like the fans of a winnowing-machine, fixed perpendicularly.

Now, the effect of these arrangements is this:—Were a common door to be made use of, whenever it was opened, free ingress or egress would be given to air, and it would pass from, or into the place, as circumstances dictated. But with a door arranged in this way, no air can at any time pass either into, or out of the place, excepting by the narrow space or crevice left between the edges of the leaves and the inside of the cylinder; since, the leaves being all at right angles with each other, and the two apertures in the cylinder being neither of them so wide as to be equal to ninety degrees of a circle of the same diameter as this door-way cylinder, it follows that, turn, or cause the leaves to revolve in what way we may, two of them will always be within the uncut parts of the cylinder, and constantly interposed between the inside of the place and the open air; and in consequence, there never can be any other passage for air into, or out of the place, by this door-way, than by the space or crevice between the edges of the leaves, and the inside of the cylinder.

When the windows and door are thus finished, I proceed as follows with the ventilator:—To the aperture in the ceiling, through which ventilation takes place, there is fixed a pipe of an equal diameter with that aperture; which pipe goes through the roof and then descends, and opens into a reservoir or cistern, situated on the outside of the building. Now, with things thus arranged, and with the cistern so far filled with water that the end of the ventilation-pipe is immersed a few inches in the water, the machinery by which the warm air is injected is set to work, when air, fresh, and of a temperature pleasant to the feelings, is injected into the bottom of the building, at a rate sufficient for the consumption of the people inside. The pipes which convey this air, are so contrived and arranged, as to distribute it over the whole surface of the floor, in a way which renders its introduction imperceptible; and consequently inconvenience from drafts or currents of it is guarded against. As fast as it is distributed over the floor, it gives place to the air that follows it, and rises towards the ventilator. In its ascent it passes the persons of the people in the place; and becoming, from the heat imparted to it by their bodies, and from the deteriorating effects of their respiration, lighter, it rises more rapidly towards the ventilator.

Now, from the arrangements and lutings I have mentioned, the only places where this air can find egress, are through the ventilation-pipe, and by the spaces or crevices between the door-way cylinder, and the leaves that revolve in it; and these spaces or crevices being, when the cylinder and leaves are well finished and fitted to each other, as almost nothing in comparison with the quantity of air injected, it follows that the ventilation-pipe must be the main channel of exit. But before any air can pass through this pipe, it must displace the water inside that end of it which is immersed in the cistern; to displace this, a slight pressure must be thrown upon it; the causing this pressure will somewhat condense the air in the ventilation-pipe; and as this condensation will, owing to that principle of fluids by which action and reaction are communicated, be reverted, or reflected back upon, and caused to take place with respect to all the air in the building, the whole of it will be somewhat condensed, and, in consequence, *the building* will have in it a quantity of air greater than

it would under common circumstances have, according to the depth to which the end of the ventilation-pipe is immersed in the water. Now, as this compressed state of the air, and the building's thus having within it more than it would under common circumstances contain, is contrary to the natural tendency of air, its expansive principle will be exerted, and every crack and crevice about the place will become a channel to let air *out* instead of *into* it; and, in consequence, drafts *into* the building effectually prevented, owing to every channel through which they used to enter, becoming a channel of *egress* instead of *ingress*.

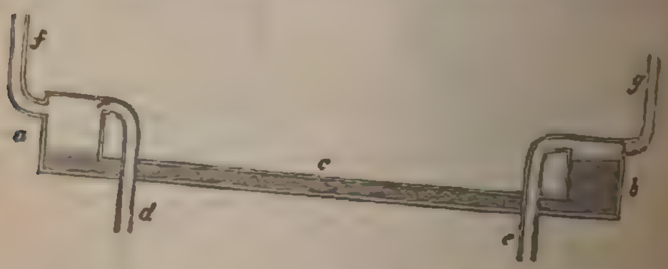
This is the way in which I prevent and do away with "*drafts;*" and when the door and ventilation apparatus (which is, in fact, nothing more than a most sensitive valve, and to which a valve would, under some circumstances, be preferable) are well arranged, and their effect not counteracted by any of the cracks and crevices which are about rooms being suffered to remain unluted, or otherwise unstopped, the evil it is intended to remedy will be effectually done away with.

There is, to be sure, both singularity, and a degree of inconvenience, in a door-way such as I have described; though, by having the panels of the revolving-leaves of glass, this might be much done away with; and as there is no other equally convenient way of preventing all possibility of annoyance from the door, whenever any one either entered or went out of the place, it might be submitted to, should common doors not be considered sufficient.

With the prevention of inconvenience, and the danger of taking cold inside the building, would also be the removal of much of the liability to cold, &c., when leaving the now highly heated atmospheres of public places; as, owing to the temperatures being always uniform, and never above that which was agreeable and salubrious, much of the danger we all experience, and many of the indispositions people of delicate constitutions incur, in consequence of passing from those atmospheres to the open air, would be done away with. And, by varying the depth of the water, in which the ventilation-pipe is immersed, according to the variations of the barometer, constant uniformity, as to the density of the atmosphere inside of the building, might be maintained."

The usual mode of ventilating ships is by a canvass bag, called a wind-sail. This is suspended over the principal aperture in the deck, and having an opening in the direction of the wind, a current is propelled downwards, which tends to purify the air. But ventilation is chiefly required in ships during foul weather, when such a process as that of the wind-sail cannot possibly be employed. Mr. Jacob Perkins has proposed, under these circumstances, the following very simple arrangement.

a and *b* represent two casks or tanks half filled with water, placed on the opposite sides of the vessel, with a channel *c*, having an open communication with both; *d* and *e* represent two large hoses or pipes, through which the foul



air from below deck escapes into the tank, where there are valves opening inward; *f* and *g* are two pipes furnished with valves opening outwards, serving to discharge the foul air out of the tanks. Now, when the tank *a* is elevated by the ship's motion, the water will run along the pipe *c* into the depressed tank *b*

the rising of the water in which will open the valve of the pipe *g*, and discharge as much air as the water displaces. At the same time the elevated tank *a* is receiving the foul air from below through the hose *d*, the valve in it having been opened by the pressure acting upon the vacuum formed in *a* by the retiring of the water, the external pressure of the atmosphere having shut the valve in the discharge-pipe *f*: now, when the vessel rocks in the opposite direction, as would be represented by a line from *d* to *g*, the charge of foul air in the tank *a*, is discharged by its filling with water in the manner already shown as respects the tank *b*; and thus the operation is continually performed by the oscillation of the vessel. It will, however, be evident that, if the tanks be fixed at right angles to the keel, the ventilation will only be effected by the *rolling* of the ship: but if the tanks be placed diagonally, then the ventilation will be equally effected by the *pitching* also. A very excellent warming and ventilating stove for buildings, particularly adapted to manufactories, by the same ingenious mechanician, is described under the article AIR: which see.

VERDIGRIS; is a crude acetate of copper, employed in the arts as a pigment; see PAINTING. It is usually obtained by moistening the surfaces of copper plates with vinegar, and exposing them to the action of the atmosphere; a bluish green rust, or fine salt, thereby forms upon the surface, which is verdigris. According to Mr. Phillips, the constituents of English and French verdigris are as follow:—

	French.	English.
Acetic acid	29.3	29.62
Peroxide of copper	43.5	44.25
Water	25.2	25.51
Impurity	2.0	0.62
	100.0	100.0

The French verdigris has been usually considered the best, but the English of late years has been so much improved in the manufacture, as to be rendered equal to the foreign in the opinion of many. In a manufactory established at Deptford, about twenty years ago, the process which we saw in operation (and which we believe is continued without any essential variation) was as follows: Thin plates of copper, of which there were an immense number, about a foot square each, were folded up in coarse woollen cloths, saturated with pyroligneous acid, (distilled on the premises;) a dozen or more such plates, with the moist cloths between them, forming one pile, were placed to the number of several thousands upon stout wooden racks, built up in an extensive cellar, through which the air had free access; but the underground situation having the effect of preserving the air in a moist state, which we understood was favourable to the process. The plates, after remaining a few days in this state, were taken down, the cloths unfolded, and the green saline matter upon the surfaces of the plates was scraped off by instruments calculated not to remove any portion of the metal; the plates were afterwards folded anew, in the moistened acid cloths, and the process was thus continually repeated, until the copper plates were by imperceptibly slow degrees worn away. The quality of the verdigris thus produced was in great estimation. The manufacture was conducted under a patent-right, which has now expired.

VERDITER. A blue pigment, obtained by adding chalk or whiting to a solution of copper in aquafortis. It is thus prepared. A quantity of whiting is put into a tub, and upon this the solution of copper is poured. The mixture is stirred every day for some hours together, until the liquor loses its colour. The liquor is then to be poured off, and more solution of copper is to be added; and the process thus continued, until the whiting has acquired the requisite depth of tint; when it may be first dried upon large pieces of chalk, and afterwards in the sun's rays. The inferior verditers are deficient of copper.

VERJUICE. An austere vinegar, made from the expressed juice of wild or crab apples. It is used by the wax-chandlers for purifying their wax. Also in French cookery, to give pungency to ragouts, &c.

VERMICELLI. A composition of flour, cheese, yolks of eggs, sugar and saffron, reduced to a smooth paste, and formed into long slender pieces like worms, by being forced through little holes, by means of a piston moving in a cylinder.

VERMILION. A beautiful scarlet-red pigment. It is usually obtained from mercury, being the red sulphuret of that metal. It is said, by some authors, that the *Chinese* vermilion is a sulphuret of *arsenic*: others, on the contrary, assert that it is prepared from the cinnabar of the East, which being an ore of mercury, already combined with sulphur, renders it an obvious and an easily conducted process. Large quantities of vermilion are manufactured by the Dutch. Their process consists in grinding together 150 pounds of sulphur, and 1000 of quicksilver, and then heating the Æthiops mineral thus produced, in a cast-iron pot, two feet and a half in diameter, and one foot deep. If proper precaution is taken, the Æthiops does not take fire, but merely cakes together, and requires to be ground. Thirty or forty pots, capable of holding twenty-four ounces of water each, are then filled in readiness with this Æthiops.

The sublimary vessels are earthen bolt heads, coated two-thirds of their height with common fire-lute, and hung in the iron rings, at the top of three pot furnaces, built in a stack under a hood or chimney, so that the fire has free access to the coated part; each sublimer has a flat iron plate, which covers the mouth of it occasionally. The fire being lighted in the evening, the sublimers are heated gradually to redness. A pot of Æthiops is then flung into each sublimer; the Æthiops instantly takes fire, and the flame rises from four to six feet high; when the flame begins to diminish, the sublimer is covered for some time. By degrees, and in the course of thirty-four hours, the whole of the Æthiops is put into the sublimers, being 410 pounds into each. The sublimers being thus discharged, the fire is kept up, so that on taking off the covers every quarter or half-hour, to stir the mass with an iron poker, the flame rises about three or four inches above the mouth of the sublimer. The sublimation usually takes thirty-six hours, and when the sublimers are taken out of the furnace, cooled, and broken, 400 pounds of vermilion are obtained from each.

Kirchoff first showed, that by commingling and triturating mercury, sulphur, and potash together, and applying heat, cinnabar might be obtained; but the process was uncertain, and gave variable quantities of vermilion. The following is a process recommended by M. Bruner:—

Mercury	300 parts.
Sulphur	114
Caustic potash	75
Water	400 to 450

The mercury and sulphur are first triturated together, from three hours to a whole day, according to the quantites used. When the mixture is homogeneous, the solution of potash is added, the trituration continued, and the mixture heated in an earthen vessel or porcelain, or, if on a large scale, of iron. At first, the stirring must be constant, afterwards, from time to time. The heat should be sustained 113°; it should never pass 122°. The liquid should not be allowed to diminish by evaporation, but be made up. After some hours, the mixture will acquire a reddish brown colour, and then great care is required: the mixture must not pass 113°. If it becomes glutinous, a little water should be added; the mixture of sulphur and mercury should always be in a pulverent form in the liquid. The colour becomes more and more brilliant, and at times increases with astonishing rapidity: when it has attained its highest intensity, the vessel is to be taken off the fire, but still to be retained warm for several hours. The time necessary for the application of heat, appears to be directed as the quantity operated upon. If the proportion above be in grammes, (about 15½ grains each,) the red colour will appear in about eight hours, and the operation be finished in about twelve hours.

The cinnabar is then to be washed, and the small quantity of metallic mercury that may be present, separated; from 328 to 330 parts of vermilion will

be obtained, of a colour, equalling that of the native cinnabar, and far surpassing that of cinnabar obtained by sublimation. The mercury and the potash should be quite pure.

VICE. An instrument consisting chiefly of a pair of stout jaws or chaps, which are brought together by the aid of a screw, to compress, or hold fast any substance placed between them. Vices are of almost indispensable utility to smiths, engineers, and the generality of mechanics, to the peculiar wants of certain classes of whom, they are sometimes variously modified: but the vices in general use, are those termed smiths' vices, and these are of several kinds; namely, the standard vice, the bench vice, and the hand vice. The first-mentioned has a long standard bar reaching to the ground, by which it may be stapled to the side of an upright post; and likewise a pair of flattened horns, by which it may be nailed to the top of the post, or to a work-bench. They are made of various sizes, and weigh from 15 to 150 pounds each, according as they may be required for heavy or light work. The second sort, bench-vices, are of a smaller class; they have no standard bar, and are contrived so as to be clamped firmly to the bench, by means of a screw and wrench, and the horns or claws above. Of this kind, a very superior quality used by watch-makers, clock-makers, and other delicate mechanists, is made by the Lancashire tool-smiths, whose workmanship surpasses all others. The third kind, hand-vices; these, though of various sizes, and modified in a thousand ways, are all so small as to be held in one hand, that the article they gripe may be worked upon by the other; the jaws are drawn together or asunder by a small thumb screw.

VINEFICATEUR. An apparatus for collecting the alcoholic vapours that usually escape from fluids during the process of vinous fermentation. It is a conical vessel or cap, covering a hole in the top of the fermenting tun, which is in other respects closed air-tight. The conical vessel is surrounded by a reservoir of cold water, so that the spirituous vapours, rising from the working tun, may be condensed when they enter the cone, and, running down its sides, be conducted by a pipe back into the tun. The cap is provided with a tube, to carry off the gaseous portion of the vapour which has not been condensed.

VINEGAR. Acetic acid in a dilute state, combined with mucilage, and sometimes accompanied with flavouring ingredients. Though frequently resulting from spontaneous fermentation, this useful acid is usually obtained by the manufacturing processes of brewing and fermentation. There are four principal kinds; namely, wine vinegar, malt vinegar, sugar vinegar, and wood vinegar. The process of preparing the last-mentioned, has been already described under the article ACID, in the first volume; our attention is therefore here restricted to the three former.

Wine Vinegar. In Paris, the wine destined for making vinegar, is usually mixed in a large tun, with a quantity of wine lees; the whole is then transferred into cloth sacks, placed within a large vat, and the liquid portion of the matter is extruded through the sacks by superincumbent pressure. What passes through is run into large casks, set upright, having a small hole in their tops. In these vessels, it is exposed to the heat of the sun in summer, or to that of a stove in winter. Fermentation takes place in a few days. If the heat should then rise too high, it is lowered by cool air, and the addition of fresh wine. In the skilful regulation of the fermentative temperature, consists the art of making good wine vinegar. In summer, the fermentative process is usually completed in a fortnight; in winter, about double the time is requisite; after which, it is run off into casks, containing some chips of birch-wood, where it is allowed to remain, until it has become clear and bright, which usually takes a fortnight more. The vinegar is then put into close casks, and is ready for the market.

At Orleans, the manufacturers prefer wine of a year old, for making vinegar; but, if the wine has lost its extractive matter, by age or otherwise, it does not so readily undergo acetification, which is, however, brought about by the addition of bunches of grapes, slips of vines, or green woods, abounding with extractive matter. Almost all the vinegar of the north of France being prepared at Orleans, the manufacture of that place has acquired such celebrity, as to render the process employed there worthy of particular attention.

[illegible] nearly 400 pints of wine. Those which have [illegible]. They are placed in three rows, one above [illegible] an aperture of two inches diameter, kept always [illegible] is kept in adjoining casks, containing beech [illegible] adhere. The wine thus clarified, is drawn off to [illegible] pints of good vinegar, boiling hot, are first poured [illegible] left for eight days. Ten pints of wine are mixed in, [illegible] casks are full. The vinegar is allowed to remain in [illegible] before it is exposed for sale. The used casks, called [illegible] emptied more than half, but are successively filled again, to [illegible] wine. In order to judge if the *mother* works, the vinegar [illegible] into the liquid; and, according to the quantity of froth [illegible], they add more or less wine. In summer, the atmosphere [illegible] sufficient. In winter, stoves heated to about 76° Fahr. maintain [illegible] temperature in the manufactory.

[illegible] districts, the people keep, in a place where the temperature [illegible], a *vinegar cask*, into which they pour such wine as they wish [illegible] is always preserved full, by replacing the vinegar drawn off, by [illegible] To establish this household manufacture, it is only necessary to buy [illegible] cask of good wine. The following mode of preparing vinegar [illegible] described by Boerhaave, more than a century ago, is still in practice [illegible] of France, and elsewhere:—

[illegible] large casks or hogsheads, and in each of these, at the distance of [illegible] the bottom, form a false-bottom of wicker-work; set the vessel [illegible] on the grate place a moderately close layer of green twigs, or [illegible] of the vine. Then fill up the vessel with the foot-stalks of the [illegible] called the rape, to the top of the vessels, which must be left [illegible] Having thus prepared the two vessels, pour into them the wine to [illegible] into vinegar, so as to fill one entirely, and the other only half- [illegible] Leave them thus for twenty-four hours, and then fill up the half-filled [illegible] liquor, from that which is quite full, and which will now, in its turn, [illegible] half full. Twenty-four hours afterwards, repeat the same operation, [illegible] go on, keeping the vessels alternately full and half full, during twenty [illegible], till the vinegar be made. On the second or third day, there will [illegible] half-filled vessel, a fermentative motion, accompanied with sensible [illegible] which will gradually increase from day to day. On the contrary, the fermenting motion is almost imperceptible in the full vessel; and, as the two [illegible] alternately full and half full, the fermentation is, by this means, in [illegible], interrupted, and is only renewed every other day in each vessel. [illegible] motion appears to have entirely ceased, even in the half-filled vessel, [illegible] that the fermentation is finished; and therefore, the vinegar is then [illegible] into casks, close-stopped, and kept in a cool place. A greater or less [illegible] warmth accelerates, or checks this, as well as the spirituous fermentation. In France, it is usually finished in fifteen days, during the summer. [illegible] of the air be very great, and exceed 25° of Reaumur's thermometer, [illegible] the half-filled vessel must be filled up every twelve hours; because, [illegible] fermentation be not so checked in that time, it will become violent, and [illegible] will be so heated, that many of the spirituous parts, on which the [illegible] the vinegar depends, will be dissipated, so that nothing will remain [illegible] fermentation, but a vapid liquor, sour indeed, but effete. The better [illegible] the dissipation of the spirituous parts, it is a proper and usual practice to close the mouth of the half-filled vessel, in which the liquor ferments, [illegible] cover made of oak wood. As to the full vessel, it is always left open, [illegible] air may act freely on the liquor it contains; for it is not liable to the [illegible] inconvenience, because it ferments but very slowly."

[illegible] observing the phenomena of this fermentation, M. Fourcroy remarks, [illegible] *of Natural History and Chemistry*, London, 1790,) we perceive a [illegible] of boiling and hissing. The liquor becomes hot and turbid, a great [illegible] bubbles and filaments appear to run through it in all directions: there [illegible] from it a lively acid smell, which is no way dangerous: it absorbs a

great deal of air. By degrees, tnese phenomena disappear; the beat falls, the emotion ceases, and the liquor becomes clear. It deposits a glareous sediment in reddish flakes, which stick to the sides of the casks. It appears, from a sufficient number of experiments, that the smaller the quantity of the wine, and the more it is exposed to the contact of air, so much the more readily does it pass into the state of vinegar. Care must be taken to draw off the vinegar clear, when it is thus prepared, in order to separate the lye, which, were this precaution neglected, would cause it to pass into the state of putrid fermentation. Vinegar does not, like wine, deposit tartar by rest: that salt was dissolved, and combined with the alcohol and water, during the fermentation. It is even probable, that the presence of the salt has a principal influence in calling forth the properties of vinegar from a latent state.

Malt Vinegar, which is chiefly used, and extensively manufactured in this country for foreign as well as home consumption, is made by macerating malt (in some instances mixed with a proportion of unmalted barley,) in hot water. From each boll of the grain is extracted one hundred gallons of wort, and when the temperature is reduced to about 75° of Fahr. four gallons of beer yeast are added to each hundred gallons. The liquor is next racked off into a series of upright vats, arranged in a stove-room, kept heated to a temperature of nearly 90° Fahr. The vats are provided with perforated false bottoms, on which is strewed a quantity of *rape*, the refuse from the makers of British wine, or some low priced raisins. Every twenty-four hours, or oftener, should the liquor grow too warm, the principal portion of the liquor of each alternate vat is pumped out, and discharged into the adjoining one, two vats being usually worked together, in the manner already described, until the active fermentation is completed. After this, the liquor is drawn off clear into large casks or pipes, which are laid on their sides, exposed to the air, the bung-holes being only loosely covered, to exclude accidental impurities.

VINERY. A garden erection, usually consisting of a wall 12 or 14 feet high, extending in an easterly and westerly direction, covered with a roof and glass lights, furnished with a stove and flues, and every convenience for the protection and cultivation of vines.

VIOLIN, or fiddle; a well-known stringed instrument of brilliant tone, the vibrations in which are produced by means of a bow.

VIOLONCELLO, or bass viol; a similar instrument in construction to the violin, but of a larger size, and having a more powerful effect. An improvement in the violoncello was lately made by Mr. S. A. Forster, of Frith Street, Soho, London, for which that gentleman received an honorary medal from the Society of Arts. The tail-piece of a violoncello is a thin board, usually of ebony, fixed at the end of the instrument, opposite to the pegs, and to which the ends of the strings are tied, or otherwise fastened. Mr. Forster's invention consists, first, in making three longitudinal cuts in the tail-piece, dividing it into four bars, united only at the lower end, sufficiently separated at the other to prevent their touching while in a state of vibration; and attaching the strings one to each of the bars. In each bar are three holes, and the string is to be fastened to whichever of them on trial shall be found to give the most perfect tone. Secondly, the material of the tail-piece, instead of being wood, as usual, is of soft hammered brass; this alloy being found to give freer vibrations than copper, and to be preferable to iron or steel, on account of the metallic quantity of tone which attends the use of these substances. By the above arrangement, each string being attached to its own bar, the string and bar form a continuous and distinct line, and therefore the vibrations of the different notes interfere less with each other. When the strings are tied to one common tail-piece, the breaking of one puts all the others out of tune; but in Mr. Forster's invention, as each string has its own bar or tail-piece, the breaking of one affects the others in a very slight degree.

VITRIOLS. A class of salts formed by earthy or metallic combinations with the vitriolic or sulphuric acid.

VOLUTE. A spiral scroll, used in the Ionic and Composite capitals of columns, whereof it makes the principal characteristic and ornament.

W.

[illegible] of dried paste, used for sealing letters. The mode [illegible] follows:—Take fine wheat flour, mix it with white of eggs [illegible] very smooth paste, and spread the same over tin plates evenly, [illegible], placing several of the plates one over the other to [illegible] surface to the wafers. When dry, the sheets of paste thus [illegible] pile, about an inch or more in depth, and cut out into circu[illegible] hollow punch, which allows the wafers to pass up its tubular cavity [illegible] themselves sideways as the cutting proceeds, which is effected [illegible]. The variety of colours that are ordinarily communicated to [illegible] to them in the paste, by the usual pigments in the dry powdered [illegible] dissolved in the water employed. As the ornamental [illegible] sealing-wax and wafers taken from gems, seals, or Tassie's copies [illegible] which was recently much in fashion, possesses some utility as a very [illegible] cement, we shall here add the mode of preparing it. A solution [illegible] glue, in water previously tinged red, purple, yellow, &c., by Brazil-[illegible] logwood, turmeric, &c. must be prepared of a proper consistence. The [illegible] of the gem, &c. must then be moistened with a little weak gum-water, [illegible] any white or coloured opaque powder is mixed; or with the gum-[illegible], and the colour in powder sifted over it; all the colour must then be [illegible] the plain parts, leaving it only in the hollows. As much of the melted [illegible] must then be poured upon the gem as can lie upon it, and be suffered to [illegible] a gentle heat; when it will shrink considerably, so as to become not [illegible] than an ordinary sheet of writing paper; it readily quits the gem, pre-[illegible] a beautiful cast of it. To use it, the folded note, letter, &c. should [illegible] on the part where the glue-wafer is to be applied, and the back of [illegible] wafer be placed on the wet part, when it will soon adhere, by its glu-[illegible] property, and thus form an elegant closure to the letter. It should be [illegible], that this is merely the revival, and application to a different pur-[illegible], of a well-known process, formerly much used for taking casts from [illegible], coins, &c.; viz. by making a solution of isinglass in proof-spirit, [illegible] it clear, and pouring it over the surface of the medal, &c. The [illegible] shrinks in drying, and will readily quit the surface of the medal; it may then either remain in its transparent state, or, by breathing upon it, a coat of leaf gold or silver may be applied to it, and thus give it the appearance of metal.

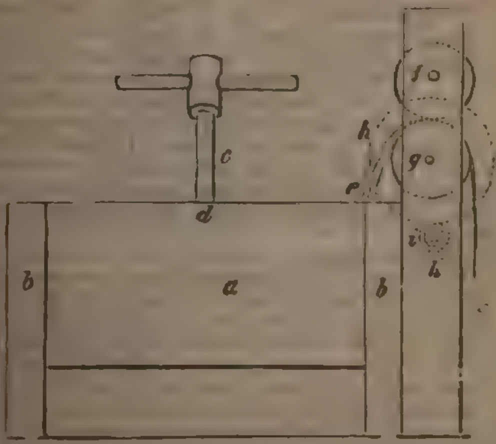
The French isinglass wafers are made in France, in the following manner. The isinglass being dissolved in water to the proper consistence, is poured out upon plates of glass provided with borders, and laid upon a level table; to pre-[illegible] the glue from sticking to the plates, a little ox-gall, or other fit material [illegible] be rubbed over them. Previous to the isinglass becoming quite dry, they [illegible] to be cut through along the borders. The leaves are then removed, and cut [illegible] with hollow punches, as other wafers are. The various colours are com-[illegible] to them by pigments while in the fluid state. They are sometimes [illegible] with essential oils and aromatics, as well as fruits, to give them an [illegible] taste. For sealing letters, these wafers afford more security than the [illegible] paste kind.

WASHING-MACHINE, in the common acceptation of the term, is an apparatus for cleansing linen, cloth, and various fabrics; there is a great diver-[illegible] of them, but one or two that we shall describe will, in a great measure, [illegible] an idea of the generality. In the annexed figure is given a section of Mr. Flint's Patent Machine for cleansing woollen cloths from dirt, and their [illegible] of colouring matter, after having been dyed. *a a* is the section of a water trough, filled with water up to the pipe *f*, by which it is supplied; *b* is [illegible] inner vessel for receiving the dirt and the colouring matter, as it falls [illegible] the cloth between the two cylinders *d d*, when pressed by the action [illegible] the upper cylinder. These cylinders are made of wood, with reeds or [illegible] along their peripheries, and revolve upon their axles, in bearings fixed to [illegible] sides of the trough, which cannot be shown in this view. The cloth *c* is [illegible] over the two lower cylinders (as a round towel) in an endless coil; the

cylinders are put in motion, by gear or by bands from any adequate first mover. By this arrangement the cloth is gently pressed between the flutes or ribs of the revolving cylinders, passing through the soapy water below in easy folds, while

the extraneous colouring matter and dirt falls and is collected in the inner vessel, preserving the water in the outer vessel from a great proportion of the foulness which it would otherwise acquire.

A few years ago, Mr. Bullman, of Leeds, whose patent mangle we have described, took out a patent also for a washing and wringing machine, combined



in one apparatus; the principal arrangements of which will be understood by reference to the above diagram. Mr. Bullman justly states that the ordinary process of wringing is *peculiarly* destructive of linen apparel, especially such as

are of a delicate texture; and, to obviate this defect, he causes the linen to be passed from the washing machine between rollers which squeeze by simple pressure the water out of them, so as to make them nearly dry.

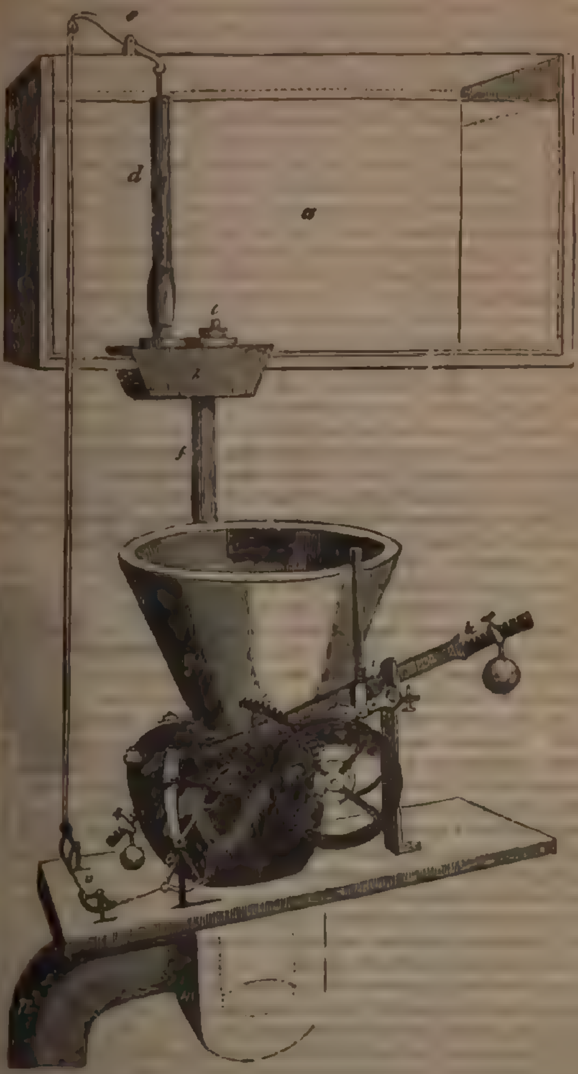
a is the vessel holding the clothes and water, standing upon stout legs *b b*: it has a circularly curved bottom, to accommodate the action of an oscillating beating frame which is put in motion by the cross handle *c*, and turns upon a fulcrum at *d*. The lines at *e* are intended to represent some of the clothes, supposed to be washed, being taken up out of the vessel by means of the rollers *f g*, between which they are compressed as they emerge from the vessel. The axis of the roller *g* carries a toothed wheel *h*, operated upon by a small pinion *i*, by turning the winch *k*. The rollers are duly provided with apparatus to adjust their distance from each other, by which the pressure is of course regulated; and they are covered with two or three coils of flannel, to give elasticity to the pressure, and prevent injury to the fabric. We have seen the machine in action, and it seems to do its duty very well. The patentee says, that by the use of the wringing apparatus alone, linen will last twice as long as when wrung in the usual manner. Washing machines for other processes are described under the subjects to which they relate.

WATER. A transparent fluid without colour, smell, or taste, and compressible only in a very slight degree; when pure, not liable to spontaneous change; liquid at the common temperature of our atmosphere, assuming a solid form at 32° of Fahr. and a gaseous state at 212° Fahr., but returning unaltered to its liquid state on resuming any degree of heat between these points. Water is capable of dissolving a greater number of natural bodies than any other fluid whatever, and especially those known by the name of the saline; performing the most important functions in the animal and vegetable kingdoms, and entering largely into their compositions as a constituent part; water exists therefore in three different states: in the solid state or state of ice, in the liquid, and in the state of vapour or steam. It assumes the solid form, as observed above, when cooled down to the temperature of 32°, in which state it increases in bulk, and hence exerts a prodigious expansive force, owing to the new arrangement of its particles, which assume a crystalline form, the crystals crossing each other at an angle of 60° or 120°. The specific gravity of ice is therefore less than that of water. When ice is exposed to a temperature above 32°, it absorbs caloric, which then becomes latent, and is converted into a liquid state, or that of water. At the temperature of 42° 5′ water is at its maximum of density; and according to some accurate experiments upon water in this state, a French cubic foot of it weighs 70 pounds 223 grains French, which is equal to 529452.9492 troy grains. An English cubic foot, at the same temperature, weighs 437102.4946 grains troy. By professor Robinson's experiments, it is ascertained that a cubic foot of water, at the temperature of 55°, weighs 998.74 avoirdupois ounces, of 437.5 grains troy each, or about 1¼ ounce less than 1000 ounces avoirdupois, which latter, however, is the usual estimate. When water is exposed to the temperature of 212°, it boils; and if this temperature be continued, the whole is converted into elastic vapour or steam. In this state it expands to about 1800 times its bulk when in the state of water, which shows what an astonishing expansive force it must exert when it is confined; and hence its application to the steam engine, of which it is the moving power. Water was formerly considered as a simple elementary substance, and the contrary was not satisfactorily ascertained till towards the end of the eighteenth century, when it was found that 100 parts, by weight, of water is composed of 85 parts of oxygen gas, and 15 of hydrogen gas. In the common tables of specific gravities, that of water is assumed as 1.000, or the unit of measurement, because, as has been already observed, a cubic foot of water weighs very nearly 1000 ounces; it follows, therefore, that the number expressed in the table as the specific gravity of any other substance, gives also the real weight of a cubic foot of such substance.

WATER, *boring for*. See Boring the Earth.

WATER-CLOSET. It was not until that important little contrivance, called the water lute or air-trap was invented, (which we have described under the last-mentioned designation) that private dwellings could be even partially secured

the annoyance of unpleasant effluvia; but however excellent may be principle of this invention, by neglect or gross mismanagement, its application was rendered a greater evil than a benefit, until the late ingenious Mr Bramah devised the apparatus, now termed a water-closet. Succeeding ingenious men materially improved it, and have given to it a variety of forms and modifications. Out of the many presented to our notice, we have selected three for description in this place, which appear to us to be deserving of public



patronage. The first we shall mention is the patent self-acting water-closet, invented by Mr. J. Downes, of High Holborn. It is put into operation by the

[illegible] seat, so as to be entirely self-acting, and [illegible] letting on the water.

[illegible] represents the water cistern, placed as usual at a [illegible] to give the water an impetus; *h* is the [illegible] supply; water enters it by the valve *e*, and air [illegible] by which a communication between the valve [illegible] as may be seen by the wires extending from [illegible] and from the other to the cranks *o o o*; *f* is the [illegible] to the basin *g*; *i* is a pushing rod attached to [illegible] back to a projection from the axis of a long [illegible] weight is placed upon the seat, the left hand [illegible] down till the pendant link at *b* catches the hooked [illegible] represented in the figure. Now it will be observed [illegible] is removed from the seat, the balance weight [illegible] link *b*, and with it the hooked lever which is attached [illegible] to a toothed sector movable on an axis which [illegible] back the soil pan, when the water is let on by the [illegible] When the upper lever rises to its greatest elevation, the [illegible] the hooked end of the lower lever, which then, by a [illegible] the toothed sector, is brought back to its stationary [illegible] shutting the valve *e*, and returning the soil pan to [illegible] basin. The quantity of water contained in the service [illegible] descends into the basin and fills up the soil pan and [illegible] basin, thus preventing any escape of effluvia from the soil [illegible] fly wheel, which is put in motion by the toothed sector [illegible] fixed on its axis, is to prevent by its inertia the water [illegible] shut off when the lower lever is liberated.

[illegible] somewhat complicated in appearance, is really simple in [illegible] manufactured by the patentee, not very liable to derangement.

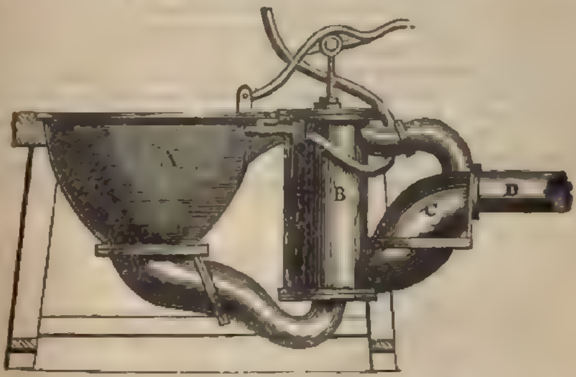
[illegible] water-closet, is of the portable kind. It represents, in its [illegible] an ornamental piece of cabinet-work. Our drawing and [illegible] course only reference to the interior. The construction is [illegible] diagram. *a* is the basin, *b* the trap or valve at the bottom, [illegible] to the bottom of [illegible] a lever for opening or [illegible] its fulcrum being on [illegible] upright brass stems, [illegible] shown at *d*. The latter [illegible] metallic casing which [illegible] and thus forms a sup[illegible] work for this part of the [illegible] The lower ends of the stem [illegible] circular checks *e*, for en[illegible] convoluted spring of a cylin[illegible] like the usual door spring; [illegible] steel, it is made of tough [illegible] brass, which pos[illegible] coiled up, considerable [illegible] is not destroyed or in[illegible] by rapid corrosion. To [illegible] attached a stem, carrying [illegible] roller, which presses

[illegible] the requisite force to keep the valve *b* shut; this force may at any [illegible] in a minute, by means of a screw on the opposite side of the [illegible] spring; if turned with a screw-driver in one direction, the force of the [illegible] increased, and if in the reverse direction, it is relaxed; and it is fixed [illegible] degree by the pall falling into the teeth of the ratchet-wheel, [illegible] centre of *e*. The method of working the valve by the action of [illegible] the essential and valuable part of the invention, and it is that on [illegible] claim of patent-right depends. The little roller, it will be observed

does not act upon a horizontal plain surface, nor against an inclined plane, but it runs upon the curved or convex surface at the end of the piece *b*; the effect of which is, that when the trap or valve is opened by the weight of the contents of the basin, or by water from the pump, the force of the spring gently relaxes, instead of increasing, permitting it to open wide, and be thoroughly cleaned; and the valve, as it returns, being operated upon by the increasing force of the spring, is thereby shut up very closely. This mode of regulating the pressure is ingenious, and produces that uniformity and certainty of effect so much desired; without which, indeed, a machine of the kind is a nuisance instead of a convenience. The dotted lines show the manner in which the apparatus is dropped into a pail. The double rim of the latter is made to contain a little water, forming a little canal all round, and the projecting rim of the former being immersed in it, an air-tight joint is thus produced, which prevents the escape of effluvia. The pail, &c. is enclosed in mahogany or other cases, wrought so as to represent various articles of the furniture of a room in the usual way.

Another very ingenious contrivance adapted to be used in a house, but especially calculated for ship-board, was invented by Mr. Downton, Blackwall; the soil being forced out of it by means of an air-pump, so that its perfect operation may be ensured in any situation, above as well as below the surface of the water.

A is the basin; B the air-pump, on the raising of the piston of which by means of the lever shown, the soil is drawn into it from A through the bent tube; on depressing the piston in B, the valve at the bottom of it closes, and a valve at C



opens, through which the soil is driven, and along the pipe D to the required distance, the soil being prevented from returning by the closing of the valve at C. In the upper part of the bason there is a small pipe leading into the upper part of the cylinder, where a valve opens inwards; consequently, in depressing the piston, the foul air is drawn from the bason into the cylinder, and on raising the piston, the foul air is forced out of the cylinder by the large bent tube shown, into the discharge-pipe D. To the pump lever the usual cranks are connected for turning on and off the clean water, supplied by the small pipe which is shown bent round the cylinder.

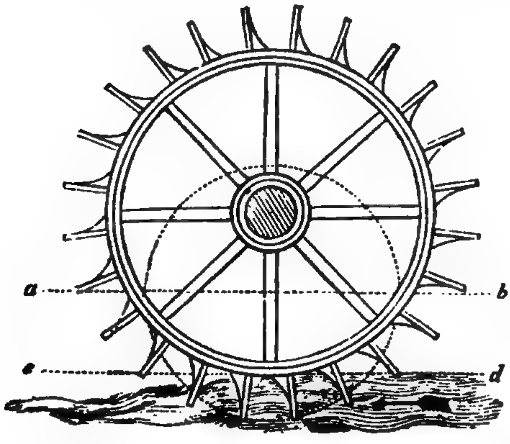
WATER-COLOURS. Pigments in which water is employed as the vehicle for painting with, in contradistinction to oil-colours, wherein oil is the vehicle: the colouring matters are the same in both cases. For water-colour painting, the pigments are ground extremely fine, and made up into elegant little cakes, with mucilage or gelatine, and may be had at the principal colour-shops in a state of great purity and beauty. See Painting.

WATER-MILL, is a general term applied to all mills moved by the force or weight of water; many of the mills or machinery described in the course of this work would be popularly called by the indefinite term, water-mills. Now, the

modes of communicating the impulse of water to the driving of machinery are various; some of these are described under the head HYDRAULIC-MACHINES; and amongst them one of great excellence, denominated the "Statical Hydraulic Engine;" and all that we have to add to the subject in this part of the work will properly fall under the designation of WATER-WHEELS, given in the subjoined article: as it is by the application of water-wheels that mills become water-mills.

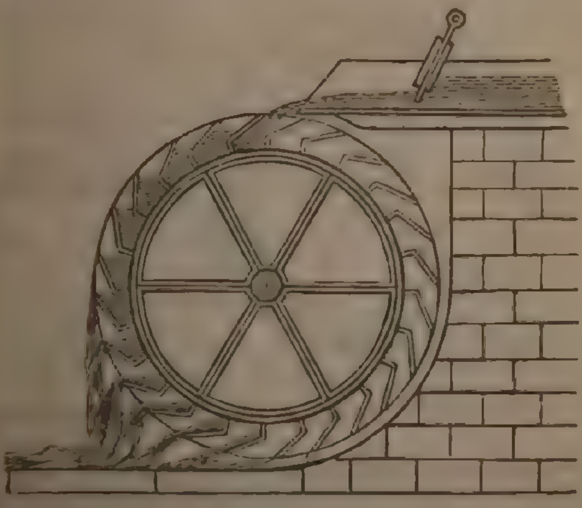
WATER-WHEEL, in the common acceptation of the term, is an instrument by which the moving force of water is employed to communicate motion to machinery; there is, however, another class of water-wheels, commonly called paddles, in which the water is employed as a stationary resisting force. The last mentioned class is described under the head of STEAM-VESSELS, in which it forms the most conspicuous feature. Under the present section we therefore confine our notice to the first-mentioned class of water-wheels, of which there are three distinct kinds, namely, the *undershot*, the *overshot*, and the *breast*-wheel. (There is usually described in books upon the subject, a fourth kind, called the *horizontal* wheel; but it is so disadvantageous an arrangement, compared to the three first mentioned kinds, that we shall exclude it from our description.

The undershot water-wheel is that commonly used in rivers and streams, and is by far the most ancient kind; it requires no other fall or inclination of the stream than may be sufficient to produce a rapid progressive motion on it; and as it acts chiefly by the momentum of the water,—its positive weight being scarcely called into action,—it is only fit to be used where there is a profusion of water always in motion. This wheel has, however, the advantage of being the cheapest of all water-wheels, and is more applicable to rivers in their natural state than any other form. It likewise works equally well whether the water acts upon the one or the other side of its float-boards; which renders it particularly applicable to tide rivers, where the current changes from one direction to the opposite one at ebb and flood. There are, however, some practical disadvantages attending this form of wheel, when made of small diameter, or the increase of water causes a large wheel to be immersed too deeply. In either case the effect is similar. Let us first suppose that the wheel delineated beneath, is immersed



in water up to the dotted line *a b*; the float-board *b* would press downward upon the water, while that at *a*, on the opposite side, would press the water upward; now these two resisting forces combined, together with the unavoidable friction of the machinery, would almost neutralize the whole force that might be derived from the current, if the water line was above the dotted line *c d*. Now in the other case of a wheel of small diameter, such as

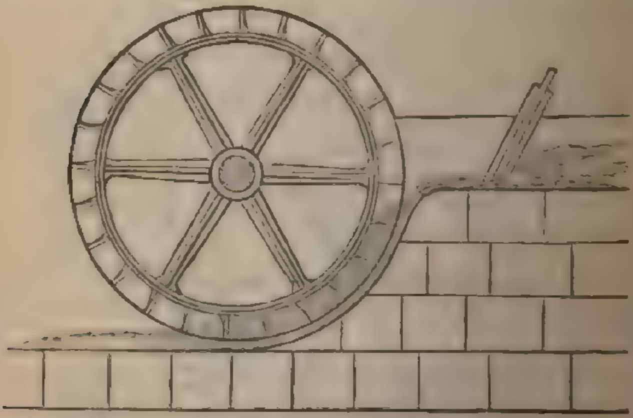
will suppose the dotted circle to represent, and the floats fixed radially und it, in the same manner and at the same distances apart as in the large l, it will be evident that a less number of floats will be submerged or exposed he action of the current; consequently, they will assume the same unfavour- position as has been described, by the deep immersion of the large wheel; that, were the small wheel immersed up to the line *a b*, which is even with its , it would not move at all, as the force or weight of water on each side ld be exactly balanced. Persons but little skilled in the principles of hanics, have attempted to gain an advantage, by placing the float-boards entially to the circle, so that the floats shall *leave* the water edgeways, and lift it up at all, as in the one we have figured; omitting to notice, or give weight to the fact, that the floats which are entering the water on the oppo- side of such a wheel are, in consequence, posited so as to strike against the er with their broad sides, which thereby counterbalance the advantage gained he other; and we submit to the consideration of those mechanics who prefer tangential to the radial position of the floats, that it is less destructive to the el and all the mechanism to which it may be connected, to receive two equal ussions of small force on opposite resisting sides of the wheel, than one con- ion of double the force upon only one side of the wheel; the direct tendency, ppears to us, is to break the arms of the wheel, close to the axis. Whenever weight and motion of water can be made use of as well as its momentum, h greater effects can be produced than the last described machine is capable nd with a much less lavish expenditure of the fluid, for then its utmost ers of action are brought into play at once; and accordingly, those water- els that are distinguished by the name of breast-wheels, and overshot wheels, produce much greater power, with a much less supply of water, than the rshot wheel already described. Both these wheels, however, require a con- rable fall in the stream upon which they are placed, and consequently de- r it for the purposes of navigation, unless that ingenious hydraulic contri- e, the CANAL LOCK, be resorted to, by means of which barges or vessels of magnitude may be transported from one level to another without difficulty, with very little loss of time. The *over-shot* water-wheel, which of all others



s the greatest power with the least expense of water, requires a fall in the m equal to rather more than its own diameter; therefore it is customary to this *description of wheel* a greater length in proportion to its height than is

given to any other,—by which an equality of power is obtained. In the construction of the over-shot wheel a hollow cylinder or drum that is impervious to water, is first prepared, and hung upon a proper central axis. A number of narrow troughs or cells, generally formed of thin plates of metal, extending from one end of the drum to the other, are next fixed round the outside of the wheel, so as to give a transverse section through the middle of the wheel the appearance shown in the preceding figure. The water is conducted by a level trough of the same width as the wheel, over its top, and is thence discharged into the buckets or cells placed round the wheel to receive it; from the particular form of these buckets, they retain the water thus thrown into them, until by their motion they descend towards the point when, their mouths being turned downwards, they discharge their contents into the tail-stream, where the water runs to waste. The buckets on the opposite side of the wheel ascend with their mouths empty, until they arrive under the end of the water-trough, to be refilled, where there is a pen-stock or sluice, for regulating the quantity of water and preventing waste; since, if the water was permitted to flow too rapidly, it would splash out of the buckets instead of filling them, and would run down over the surface of the wheel, without producing its proper effect. To prevent this, the water is seldom permitted to run upon the wheel in a stream of more than from half an inch to an inch in thickness, and when well regulated there is scarcely a drop of water ineffectually used. The overshot wheel acts, therefore, by the gravity or weight of the water contained in the buckets, for nearly one-third of its circumference; and from the experiments of Mr. Smeaton, which were made with great accuracy, it appears that the dimensions, quantity of water, and height of fall being the same, the over-shot wheel will produce double the effect of the under-shot.

The breast-wheel is by far the most common, and may be considered as a mean between the two varieties before mentioned. In this, the water, instead of passing over the top of the wheel, or entirely beneath it, is delivered about half-way up it, or rather below the level of the axis; and the race or brickwork upon which the water descends is built in a circular form, having the same common centre with the wheel itself, so as to make it parallel to the exterior



edges of the float-boards, or extreme circumference of the wheel. This construction is shown in the above figure, which represents a side-view of a wheel formed with float-boards in the same manner as the undershot wheel; but instead of the water acting upon its lower part, it is introduced upon it midway, by the sluice or pen-stock, which, by rising or falling, permits a greater or less quantity of water to act on the wheel; and as the float-boards are made to

fit as accurately as possible, without contact, into the circular hollow of the brick-work, no water can escape past the wheel, without producing its proportionate effect.

Mr. Smeaton states, that all wheels by which the water is prevented from descending, unless the wheel moves therewith, are to be considered of the nature of over-shot wheels, having power in proportion to the perpendicular height from which the water descends; while all those that receive the impulse or shock of the water, whether in an horizontal, perpendicular, or oblique direction, are to be considered as under-shots. The breast-wheel is nearly allied to the over-shot; for notwithstanding it has only float-boards, instead of buckets, yet as the mill-course is made concentric to the outside of the wheel, and is not only there, but at the two sides, made as close as convenient, so as to prevent the escape of water as effectually as possible, the spaces between one float-board and another, become buckets for the time being, and retain the water, and thus the breast-wheel is not only impelled by the weight of water, but by its impetus or momentum also; for the water is so confined, as to be incapable of splashing or being lost, and consequently, its moving force may be exerted to great advantage. Notwithstanding this apparent superiority, still the breast-wheel is, in effect, vastly inferior to the over-shot wheel, not only on account of the smaller height at which the water is supplied, but from the waste with which it must always be attended, even under circumstances of the most perfect workmanship. When well-constructed, and closely built in, its effect, according to Mr. Smeaton, should be the same as an under-shot wheel, whose head of water is equal to the difference of level between the surface of the stream and the point where it strikes the wheel, added to the effect of an over-shot wheel, whose height is equal to the distance from the striking point, to the tail-water of the mill, or that which runs to waste. This is, however, on the presumption that the wheel receives the impulse of the water at right angles to its radii, and that every thing is constructed to the best advantage. In practice, it is found that the breast-wheel consumes about double the quantity of water that the over-shot wheel requires, to do the same quantity of work, when all things are alike,—that is to say, the diameter and breadth of the wheel, number of float-boards, &c.,—though from theory and calculation, it should rather do more; for Lambert, and others who have written on this subject, attempt to demonstrate, that the power of the over-shot, to that of the breast-wheel, is as thirteen to five; but this is upon a supposition, that no water escapes ineffectually, which is utterly impossible in practice. In order to permit any of the above wheels to work with freedom, and to the greatest advantage, it is absolutely necessary that the tail-water, as it is called, or that which is discharged from the bottom of the wheel, after it has produced its effect, should have an uninterrupted passage to run away; for whenever this is not the case, it accumulates, and forms a resistance to the float-boards,—and consequently, abstracts considerably from the velocity and power of the wheel, sometimes indeed to so great an extent, as to prevent its working altogether. One of the simplest and most effectual means of removing this inconvenience, (says the author of the *Treatise on Hydraulics*, in the "*Library of Useful Knowledge*," for whose observations we are largely indebted in the present article,) is by an expedient, not much known or practised, and which consists of forming two drains or tunnels through the brickwork or masonry, at each side of the water-wheel, whatever may be its construction, so as to permit a portion of the upper water to flow down into the tail or lower stream immediately in front of the wheel. The water thus brought down with great impetuosity, drives the tail-water before it, in such a manner as to form a basin or hollow place, in which the wheel can work free from interruption, even if the natural state of the water were such as might produce a tailing of from twelve to eighteen inches, without this assistance. And since the tailing of mill-streams only occurs in the winter seasons, or at times when there is a profusion of water, so the quantity that is thus thrown away without operating upon the wheel, can be spared without inconvenience. Each of the drains or tunnels is furnished with a sluice-gate or pen-stock at its upper end, by which the quantity and impetus of the water can be regulated at pleasure, or the whole be shut off, whenever water happens to be scarce.

The three varieties of water-wheels already noticed, are the only ones generally admitted into practice, and they do not admit of much improvement, since their principles must always remain the same. The over-shot wheel has, perhaps, been brought nearer to perfection than any of the others, by the contrivance of Peter Nouaille, Esq. who, in a mill that he has near Seven Oaks, in Kent, has caused the water to revert back again from the top of the wheel, instead of passing over it; and in this way a much greater portion of the circumference of the wheel is brought into action than is generally the case. Other improvements or variations in the form and construction of water-wheels, have been contrived by Mr. Besant, Mr. Smart, Mr. Perkins, and others, which will be found described in the *Transactions of the Society for the Encouragement of Arts, Manufactures, and Commerce;* the object of them principally being to obtain as much force as possible from the water, by arranging the forms of the buckets or float-boards, in such manner that they may receive the greatest impulse or retain the greatest quantity of water, which is of great importance, particularly in the construction of under-shot wheels, which act by the impulse of the water alone. The over-shot wheel depends entirely on the weight of the water delivered into its buckets, which ought, therefore, to be as capacious as they can conveniently be made,—not only that they may contain as much water as possible, but allow ample room for the discharge of the air that will be thrown into them with the water, as well as for the delivery of that water, when done with. From the nature of a water-wheel, it will be evident, that if it had no work to perform, or resistance to overcome, it would move with the same velocity as the stream that drives it; while, on the contrary, if it was loaded with a quantity of resistance, equal to the power of the stream, it could not move at all: hence, every degree of resistance between these extremes, will produce its proportionate retardation of the wheel; and from accurate experiments which have been tried, it has been determined, that an under-shot wheel does its maximum quantity of work, when its circumference moves with between one-half and one-third of the velocity of the stream that drives it. The over-shot wheel cannot be so influenced by the velocity of the water, because it requires all its buckets or cells to be filled in succession; and Mr. Smeaton has determined, that the best velocity to effect the above purpose, is three feet in a second. Having, therefore, previously determined the quantity of water which the stream will deliver in a given time, it becomes a matter of easy calculation to determine the length and capacity of the buckets which shall be capable of carrying off the water at that velocity. Thus, for example, if the stream is found to deliver ninety-six gallons per second, and it is determined to make the buckets on the wheel six inches apart from one partition to another, and fifteen inches deep, then six such buckets will be contained in every three feet of the wheel; therefore, ninety-six gallons must be divided by six buckets, which gives sixteen gallons for the contents of each. It will, therefore, only remain to be determined, how long a vessel of six inches wide, and fifteen inches deep, must be, to contain sixteen gallons, and this will, of course, give the necessary width of the wheel, while the number of buckets must depend upon the circumference, which is always limited by the diameter, being the extreme height (if necessary,) that can be obtained in the fall of water; for the larger the wheel the greater will be the power derived from it, provided a due velocity can be maintained at the same time; because the power of water on wheels, is as the square root of the height it falls through, it being regulated by the same laws as apply to solid bodies in falling. The power of every wheel, of course, depends upon the quantity of water thrown upon it, and the height from which it has to fall; but as every bucket must be filled, or every float-board struck by the water in succession, so, of course, if the wheel is too large, it will move too slowly for the purpose for which it is intended; and, in this case, the speed must be raised by cog-wheels within the mill, which, on the common principle of mechanism, must dissipate the power intended to be gained by the magnitude of the water-wheel. Hence, great attention should be paid in the construction of mills, to let the size of the water-wheel be well-proportioned, not only to the velocity of the stream, but to the speed of the work it is required to perform; and this may

always be accomplished without waste or difference of power, by using a wider wheel of small diameter, where great speed is necessary, or a narrow wheel of great diameter, when this is not essential. In every case, the full power of a stream should be taken advantage of, in the first erection of a mill, because it is a troublesome and expensive operation to increase the power of a mill, when once built; and power is always valuable.

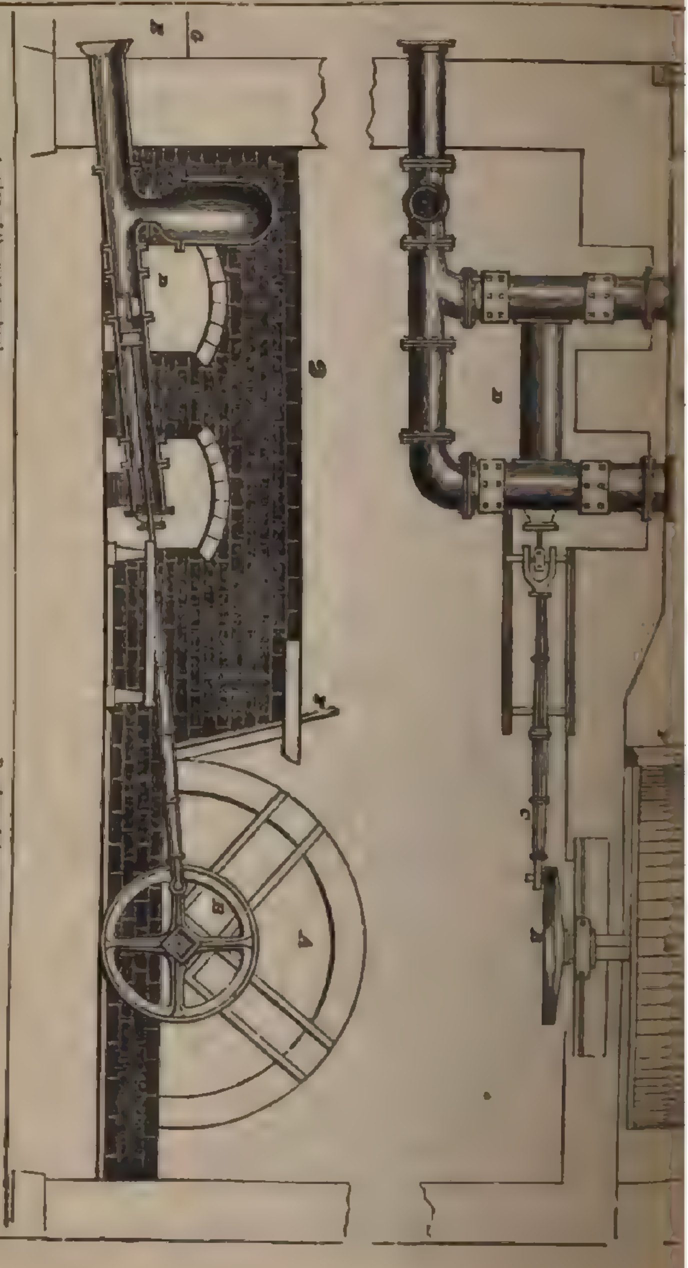
Mr. Banks, in his excellent *Treatise upon Mills*, gives many useful practical rules; from amongst which the following is selected. Being simple, it may prove useful for determining the quantity of water that will flow through a sluice or pen-stock upon a wheel, with sufficient accuracy for most purposes, because the whole motion of a stream must not be taken when it is principally dammed or stopped, and only permitted to flow through a small orifice, to produce mechanical effect.

Rule.—Measure the depth from the surface of the water to the centre of the orifice of discharge, in feet, and extract the square root of that depth; multiply it by 5.4, which will give the velocity in feet per second, and this, multiplied by the area of the orifice (also in feet,) will give the number of cubic feet which will flow through in a second. From knowing the quantity of water discharged, and the height of fall, not only the size of the wheel, but its extent of power may be calculated; for, in the undershot wheel, the power is to the effect nearly as 3 to 1; while in the over-shot wheel it is double, or as 3 to 2.

WATER-WORKS, denote all manner of works employed in raising or sustaining water; in which sense water-mills of all kinds, pumps, wheels, hydraulic engines, sluices, aqueducts, &c., described in various parts of the work, may be called water-works. The various water-works in and about London consist of pumps worked by steam-engines. The principal are those of the New River Company, whose works at Clerkenwell and Upper Thames-street, are said to furnish daily to 67,000 houses, 13,000,000 of gallons; the East London water-works, situated at Old Ford, also daily supply to 42,000 houses, 6,000,000 of gallons; the West Middlesex works at Hammersmith, to 15,000 houses, 2,250,000 gallons; the Chelsea works to 12,400 houses, 1,760,000 gallons; The Grand Junction, also at Chelsea, to 7,700 houses, 2,800,000 gallons. From which statement it appears that the portion of the town on the *north* side of the Thames, is supplied daily with about 26,000,000 gallons of water, and that the total number of buildings of all kinds receiving this supply amounts to about 144,000 The water is, from the great demand of certain factories, and various other circumstances, very unequally distributed; but the average consumption for each house is about 180 gallons. Of this water, more than one half of which is derived from the Thames, a large portion is delivered at very considerable elevations above the level of the river, even to the tops of the highest houses in the highest parts of London, by means of force pumps, called the *high service*, for which distinct service fifteen steam-engines are employed, exerting a power of 1105 horses.

On the *south* side of London, there are three water-companies, namely, the Lambeth, the Vauxhall or South London, and the Southwark. The Lambeth water-works are situated upon the banks of the Thames, and the water is forced immediately from the river into the mains, and thence distributed to 16,000 tenants, who consume 1,244,000 gallons daily. The Vauxhall, or South London works, situated in Kennington Lane, have about 10,000 tenants, who daily consume about 1,000,000 gallons. The Southwark works, upon the banks of the river, between Southwark and London bridges, supply about 7,000 tenants with 720,000 gallons of water. Each of these establishments has two engines, the aggregate power of which is about 235 horses. The whole of the water amounts to nearly 3,000 000 gallons, supplied to 33,000 tenants. The total quantity of water required for the whole metropolis, north and south of the Thames, is therefore about 29,000,000, supplied to 177,000 houses or tenants, making an average quantity of 170 gallons to each daily!

We have thus given a summary of a more voluminous statement that has appeared in most of the scientific journals, professedly derived from the printed report of a parliamentary commission, appointed a few years ago to inquire into



A, plan of the water-wheel.
B, crank-wheel.
C, connecting-rod from the wheel to the pump.
D, plan of the pump.
E, the fore bay, which supplies the wheel and pump.
F F the gates to the fore-bay and water-wheel.

subject. But we think that every resident of London, after a moment's ...ideration of the statement made out by the water companies, of their supply, ... deem it to be a most overcharged statement of facts. Our own observation ...a great number of houses, leads us to the conclusion, that instead of 170 ...ons to each house *daily*, there is not that quantity delivered *weekly* in a majority ...ases, or upon an average of the whole. If the water were turned on *daily* to all ...enants, and the discharge-cocks to all the pipes were prevented from shutting ...ing the period of "laying on," the pipes would be capable of delivering the ...ntity mentioned. But the facts are, that a great number of the cocks are ..., the cisterns being full; that the majority of them are only open for a few ...utes, to receive an addition of a few gallons; and that, so far from being a ... supply to all, the third, fourth, and fifth-rate houses (which constitute the ...rity,) receive their supplies but *twice a week* at the utmost, and many of ... but *once*. The official statements appear to us to be so grossly incorrect that ...have not thought it needful to enter into a minute investigation. Nevertheless, ...onsider the supply generally to be abundant for all the purposes of health ...comfort. We have already observed, that pumps are the machines now ...lly employed in water-works, for raising the water; and these pumps are ...rally worked either by steam or a fall of water. Having in other parts of ...work treated of the constituents of water-works, we shall conclude this ...le by a brief notice of the water-works lately erected to supply the city of ...adelphia with pure fresh water, and which have been described in the recent ...ntific journals. "These works," Dr. Jones states, "have been admired by ...who have seen them, as monuments both of the taste and skill of the per... concerned in the plan and erection of the buildings, and in the construc... and executing of the machinery." The establishment is at Fair-mount, ... miles above the city, at the Falls of the Schuylkill. The entire expense, ...uding the purchase of the site, is 426,330 dollars. The water power created ...lculated to be equal to raise into the reservoir, by eight wheels and pumps, ...ards of ten millions of gallons daily, and it is estimated that 40 gallons upon ...wheel will raise one into the reservoir. There are two reservoirs, one having ...capacity of three millions of gallons, and the other of four millions. The ...er is raised 56 feet above the highest ground in the city, and is conveyed and ...ibuted in cast iron pipes of American manufacture. A plan and section of ...pumps and water-wheels are given in the foregoing page. The pumps are ... are called double forcing-pumps, (see the article PUMPS,) producing an ...l effect in raising water, in whichever way the piston moves. The working ...el is 16 inches in diameter in the clear, and the half stroke of the pump is ... feet, giving a ten-feet stroke for each revolution of the water-wheel, of which ... are thirteen in a minute. The water is forced to a perpendicular height ...6 feet, through mains of nearly 300 feet in length. The quantity raised by ...pump, in 24 hours, is upwards of $1\frac{1}{4}$ millions of gallons, ale measure.

...r. Buchanan, in his *Journey from Madras through the countries of Mysore*, ...gives a description of the Saymbrumbacum tank near Madras, which ap...s to us well deserving of the attention of persons interested in the construc... of water-works, as there are probably situations in this country where similar ...antages might be taken of the natural configuration of the hilly districts. The ...mbrumbacum tank has not been formed by digging, like those in Bengal, ...by shutting up, with an artificial bank, an opening between two natural ...es of ground. The sheet is said to be seven or eight miles in length, and ... in width, and in the dry season is let out in small streams, as wanted, for ...ation. In the rainy season it receives a supply of water from the river Chir..., and from several small streams that are collected by a canal. It is provided, in ...erent places, with sluices or weirs, of stone, which are from 20 to 30 feet wide, ...some feet lower than the other parts. On the surface they are strongly fortified ...arge stones, placed in a sloping direction, so that the water rushes over with... undermining the bank, and is conveyed away from the fields by a canal. ... is a matter of the utmost importance, as there are instances where, the ...s of these large tanks having given way, whole villages have been destroyed

as the torrent. In order, however, that when there is plenty of rain the tank may be completely filled, a row of stone pillars is placed on the top of the sluices (weirs); and on the water rising to a level with their base, a temporary wall is formed of mud, sticks, and straw, placed between the pillars so as to confine the water till it rises as high as the top of the bank. People watch this night and day, in order to break down the temporary bank should any additional rain endanger the whole. The water is let out to supply the fields, by a sluice lined with cut stone or bricks, formed through the bank, on a level with the country. The inner end of this sluice is covered by a flat stone, in which is cut a conical opening, that can be shut or opened by a conical plug or valve, fixed to a bamboo staff, and which is secured in its place by passing through holes made in cross guiding-bars, let into two pillars of stone, which rise above the level of the water in the tank. This tank is said to be sufficient to supply with water the lands of thirty-two villages, for eighteen months, should the rains fail; such a reservoir is therefore of inestimable value.

WAX. An oily concrete matter, usually considered to be gathered by bees from plants; though Huber, who was a close observer of nature, and the habits of bees in particular, asserts that wax is an artificial production, made by the bees from the honey they collect; that they cannot procure it, unless they have honey or sugar for the purpose; and that raw sugar affords more than honey. Wax was long considered to be a resin, from some properties which it possesses in common with resins. Macquer found that wax resembles resin only in being an oil, rendered concrete by an acid; but that it differs essentially from these in the kind of the oil, which, in resins, is of the nature of essential oils, while in wax, and other analogous oily concretions, (as butter of cocoa, butter of milk, fat of animals, spermaceti, myrtle wax,) it is of the nature of mild unctuous oils, that are not aromatic, and not volatile, and are obtained from vegetables by expression. Dr. Ure considers it probable, that the acidifying principle, or oxygen, and not an actual acid, may be the leading cause of the solidity, or low fusibility of wax; but it has been observed, that by digesting the nitric or muriatic acid upon fixed oils, the oils pass into a state resembling wax. The natural colour of wax is yellow, and it is whitened by exposure, in thin laminæ, to the air and sun. Alkalies dissolve wax, and render it miscible in water. In China and North America, wax is procured directly from plants, and is then called vegetable-wax. In order to obtain bees' wax in a pure state, what remains of the combs, after separating the honey, is put into a copper, with a quantity of water, which is made to boil over a slow fire, and stirred frequently with a stick. When the wax has been thus thoroughly melted, it is strained through canvas bags, and the residue in the bags is forced out by a press, whilst hot, and received into a vessel of water. When all the wax has been thus cleared of the grosser impurities, it is again melted over water, and the scum which arises in the boiling is carefully skimmed off; after which, it is poured into pans or moulds of the size required, to solidify. Wax keeps better in large cakes than small ones: any sediment that may remain at the bottom of the cakes is scraped off before bleaching.

The ordinary process of bleaching wax, consists in first melting it at a low heat, in a cauldron, from whence it is allowed to run out by a pipe at the bottom, into a capacious vessel filled with cold water, in which is fitted a large wooden cylinder, that is made to turn round continually on its axis, upon which the melted wax falls. The surface of the cylinder being constantly wet, the wax does not adhere to it, but lays solid and flat, acquiring the form of ribbands. The continual rotation of the cylinder carries off these ribbands as fast as they are formed, and distributes them through the tub. The wax is then put upon large frames covered with linen cloth, which are supported about eighteen inches above the ground, in situations exposed to the air, dew, and the sun. The thickness of the several ribbands, thus placed upon the frames, ought not to exceed an inch and a half, and they ought to be removed from time to time, in order that they may all be equally exposed to the action of the air. If the weather be favourable, the colour will be changed in a few days. It is then to be

re-melted, formed into ribbands, and exposed to the air as before. These operations are to be repeated, until the wax is rendered perfectly white; after which it is to be melted into cakes, or formed into candles.

Of late years, the sulphuric acid, and other chemical agents, have been proposed for shortening the process of bleaching wax, but we are inclined to believe that they have not been successfully carried into practice, as the manufacturers, we are informed, adhere to the old process above described. To what extent chlorine has been applied to this purpose, or in what manner, we are not informed; but the process employed by Mr. Davidson, of Glasgow, and recently patented by him, is stated, in the specification, to be as follows:—

"The wax or tallow is heated to about the temperature of boiling water, in an iron vessel lined with lead, when the oxymuriate of lime, (chloride of lime,) or the oxymuriate of magnesia, (chloride of magnesia,) is to be added, either in solution with water, or in the dry state, and then intimately mixed and well stirred up with a wooden spatula. When these materials have acted upon each other a sufficient length of time to discharge the colour from the wax or tallow, the lime or magnesia is to be removed, by adding dilute sulphuric acid, or some other acid possessing a greater affinity for those earths than chlorine. The whole is then to be boiled, until the earth employed is separated."

For the bleaching of wax, the solution of the chloride is to be in the proportion of from 14 to 28 pounds of the salt, to 112 pounds of water; and an equal quantity by weight, of the solution and of the wax, to be employed in the process. The sulphuric acid should be of the specific gravity 1.8485, and be diluted with from twenty to thirty times its weight of water.

For the bleaching of tallow, a solution of chlorine, of less strength than the above, will suffice, and the sulphuric acid should be more plentifully diluted: but the proportions necessary, will vary both in the wax and the tallow, according to the quantity of colouring matter that may be combined with them. The following formulæ for the composition of the various kinds of sealing-wax, will not be out of place:—

The best hard red wax for sealing letters:—Mix two parts of shell-lac, well powdered, with resin and vermilion, each one part, and melt this combined powder over a very gentle fire: when the ingredients are thoroughly incorporated, work the mass into sticks. Seed-lac may be substituted for shell-lac; and instead of resin, boiled Venice turpentine may be used. Coarse hard red sealing-wax:—Mix two parts of resin, one part of shell-lac, vermilion and red-lead together one part; the latter in the proportion of one of vermilion to two of the red-lead. For a cheaper kind, the vermilion may be omitted, and for very coarse uses, the shell-lac also. Black sealing-wax is made in the same manner as red, with the exception of the colouring; the colouring ingredient for black wax, being the finest ivory black. Hard green sealing wax is the same mixture of resins and gum-resins as before-mentioned; the colouring ingredient is powdered verdigris; for a brighter colour, crystals of verdigris. Blue sealing-wax:—Use smalts, light blue verditer, or a mixture of both. Yellow sealing-wax:—Use massicott; for a fine bright yellow, turbith mineral. Purple sealing-wax:—Use half vermilion, and half smalts, or red and blue in various proportions, according to the tint required.

Particular attention should be paid to the ingredients, while over the fire, that no more heat be given than is just sufficient for them to melt, and be thoroughly incorporated. The wax is formed into sticks, by rolling it on a copper plate or stone, with a rolling-board lined with copper or tin, into rolls of any required size. The polish or gloss is given afterwards, by placing the sticks of wax over a fire in a small stove, which is provided with a suitable apparatus for placing and turning them in that situation, where the heat given to them is just sufficient to melt the surface of the wax, and produce the gloss.

A patent was recently taken out by Mr. Wason, of the Middle Temple, for introducing a small wick into the middle of the sticks of wax, for the convenience of sealing letters. These sealing-wax candles we do not, however, perceive in the shops.

WEAVING, is the art of working a web of cloth from silk, cotton, or other

fibrous thread, in a loom, with a shuttle. The principle of the art may be said to consist in crossing two sets of threads at right angles to each other; and it was probably first conducted in an extremely coarse and simple manner, like the interlacing or platting of rushes to form mats. An uninformed savage having effected thus much, would naturally be led to operate upon finer materials, which nature might present to his hands, and he would be able to weave them with the same, or nearly the same facility, as he did the coarse matting; the assistance which he might receive from a fellow-labourer, in perhaps opening the threads of his warp with a piece of stick, or in thrusting the weft through its interstices; would naturally suggest the use of sticks, for opening the alternate threads of the warp, and beating up the weft. For want of assistance, our primeval weaver might fasten the ends of his warp, which we will conceive to have been long stripes of the inner bark, to the stumps or boughs of trees. With his sticks he would then be able to operate with comparative rapidity and excellence; and as it could not fail to escape his notice, nor that of the by-standers, that the alternate threads of the warp, divided into two distinct sets, were alternately raised and depressed by the sticks, and that, sometimes, from accidental circumstances, some of the threads of the warp were raised or depressed by a pull instead of a push; hence we may imagine that some contrivance resembling or performing the same office as the treadles or lams of our present looms, were resorted to; thus we have a complete, though rude machine, excepting the shuttle; the gradual steps to which pretty contrivance must obviously have been made, by the weaver first poking, next sliding, and, finally, as his manual dexterity increased, *throwing* the weft.

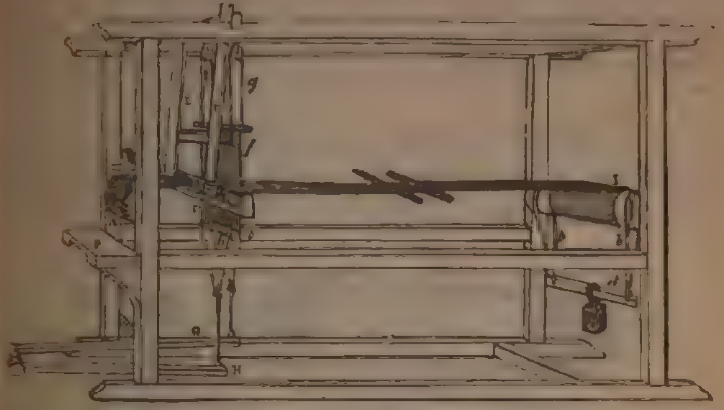
As the early history of weaving is involved in total obscurity, we have thus endeavoured to trace the probable origin and earliest practice of the invention, and at the same time explain the really simple process of which plain weaving consists. In fact, the process is even now conducted in India, and many of the eastern nations, by similar means; the weaver performs his labour in the open air, choosing his station under trees, whose shade may protect him from the scorching rays of the sun. Here extending the threads which compose the warp of his intended cloth lengthwise, between two bamboo rollers, which are fastened to the turf by wooden pins, he digs a hole in the earth large enough to contain his legs when in a sitting posture; then, suspending to the branch of a tree the cords which are intended to cause the reciprocal rising and depressing of the alternate threads of his warp, he fixes underneath, and connected with the cords, two loops, into which, inserting the great toe of either foot, he is ready to commence his operations. The shuttle with which he causes the cross threads or woof to interlace the warp, is in form like the knitting needle, and, being somewhat longer than the breadth of the warp, is made to perform the office of a baton, by striking the threads of the woof close up to each other. With this rude apparatus the patient Indian succeeds in weaving fabrics which for delicacy of texture, cannot be surpassed, and can hardly be rivalled, by the European weaver, even when his labours are aided by the most elaborate machinery.

The machinery by which the process of weaving is conducted in this country varies but little, whatever may be the material of the fabric; the difference in looms for weaving silk or wool, chiefly consisting in the greater stability and strength of the latter, on account of the greater coarseness and elasticity of the [illegible] and the thickness of the cloth woven.

Of late years there have been numerous and great improvements in weaving machinery, and these have, to a great degree, superseded the mechanism of the last century. Nevertheless, the old-fashioned common loom, for weaving plain silks, being still extensively used, especially in Spitalfields, we shall commence our account of the mechanism employed, by giving a description of it.

A, in the annexed figure, is a roller called the cloth-beam, on which the cloth is wound as it is wove; at one end it has a ratchet wheel, and a catch, to prevent its running back: at the same end it has also four holes in it, and is turned by putting a stick in these holes: at the other end of the beam is another roller I, on which the yarn is wound; this has two small cords *b b*

wrapped round it, the ends of which are attached to a bar *d*, which has a weight hung to it; by this means a resistance is caused, which prevents the roller I turning by accident. F *f* are called lames; they are each composed of a pair of sticks, between which are fastened a great number of threads; to the bar *e* are fastened two cords *g l*, which pass over pulleys, and are fastened to the bar *h* of the lame F; the lower bars of each lame are connected by cords with the treadles G H; the workman sits on the seat P, and places his feet upon these treadles: as they are connected together by the cords *g l*, when he presses down one, it will raise the other, and the lames with them; a great number of threads, according to the width of the cloth, are wound round the yarn beam I and are stretched to the cloth-beam A; the middle of the threads



which compose the lames E F, have loops called eyes in them, through which the threads between the rollers, which are called the warp, are passed; the first thread of the warp goes through the loops of the lame E, the next attached to the lame F, and so on alternately; by this means, when the weaver presses down one of the treadles with his foot, and raises the other, one lame draws up every other thread, and the other sinks all the rest, so as to make an opening between the sets of thread. L L is a frame moving on a centre at the top of the frame of the loom; L L are the two uprights of the frame; *l* is the bar that connects them; M is a frame carrying a great number of pieces of split reed, or sometimes fine wire, at equal distances; between these the threads of the warp are passed; the frame being supported by a piece of wood called the shuttle-race, which is fastened into the front of the pieces L L; each end of this piece has boards nailed to the sides, so as to form troughs; at a small distance above these are fixed two very smooth wires; their use is to guide the two pieces *p q*, called peckers or drivers; to each of these pieces a string is fastened; and these strings are tied to a piece of wood, which the weaver holds in his hand, and, by snatching the stick to either side, draws the pecker forwards very quick, and gives the shuttle (which is to be laid in the trough before the pecker,) a smart blow, and drives it along across the race *m* into the other trough, where it pushes the pecker along to the end of the wire, ready for the next stroke, which throws it back again, and so on. The ends of the shuttle are pointed with iron; it has a large mortise through the middle of it, in which is placed a quill containing the yarn; also a glass eye, having a hole in it, through which comes the end of the thread; and two small wheels to make it run easily on the race. The operations are as follow:—The workman, sitting upon the seat P, holds the stick in his right hand, and takes hold of one of the bars of the frame L L with his left; presses his foot on one of the treadles G H, which by means of the lambs E F, as before described, divides

[illegible] the treadle he before kept down, and presses down [illegible] this he with his left hand draws the frame L L [illegible] returns it. The use of this is to beat the last thread [illegible] close up to the one that was thrown before it, by the [illegible] has brought the frame L L back to its original position, [illegible] warp by the treadle, he throws the shuttle again; when [illegible] finished about twelve or fourteen inches of cloth, he winds [illegible] roller A with the stick, as before described. Some very [illegible] and throw the shuttle, and perform the other operations, at the [illegible] per minute.

[illegible] of the common kind, great difficulties have been experienced in [illegible] thread or yarn to come off the bobbin or shuttle-cap with an uniform [illegible] which it is impossible to produce a good and even cloth; to remedy [illegible] Mr. Gosset, of Clerkenwell Green, lately invented an improved [illegible] which he obtained a patent; and as the construction of these shuttles [illegible] equally applicable to weaving all kinds of materials, including the [illegible] cloth, or wire gauze, we annex the following description of them, from [illegible] specification :—

[illegible] annexed figures, 1 represents a longitudinal section, and 2 a transverse [illegible] of the improved shuttle; in this example, adapted to the weaving of [illegible] fabrics, or other stiff materials, *a a* is the body of the shuttle, made [illegible] hard wood, and tipped with metal at the extremities, as usual; *b* is the bobbin [illegible] roller, made like a pulley, and turning upon a polished pin passing

1

2

through its axis, in the morticed cavity *c*, made in the side of the shuttle; the [illegible] is adapted to be taken out easily, that the bobbin may be removed or [illegible] with facility, as often as may be desired; *d* is the regulating spring [illegible] mentioned, the ends of which are bent round and fixed, by driving them into the wood. To this large spring is fixed a smaller spring *e*, so curved as to [illegible] and press upon the upper surface of the bobbin; at *f* is an adjusting screw, the head of which is sunk into the upper part of the regulating spring *d*, to prevent its becoming entangled with the threads of the warp; the point of this screw is inserted, and works in a fixed nut in the inside of the shuttle, so that when it is turned, the small curved spring is caused to press with more or less force upon the surface of the bobbin, thereby creating a greater or less degree of [illegible] for regulating the tension at which the yarn shall be drawn off the bobbin, and through the eye *g*, of the shuttle. The upper and lower surfaces of the shuttle are formed concave, (as shown by *Fig.* 2,) in order that the [illegible] the adjusting spring may be sunk within it, so as to prevent their coming in contact with the threads of the warp. The regulating spring is in some cases applied by the patentee within the cavity *c*, when a hole is made in the upper part of the shuttle, for the insertion of a turn-screw, to operate upon the head of the [illegible] *f*, and regulate the tension. By another modification, the patentee forms [illegible] shuttle like a box, with the lid sliding in grooves, or hinged on; in which [illegible] the regulating spring is to be fixed on the lid, or one of the sides, so as to [illegible] the required pressure to the bobbin. In weaving articles of stiff wire, with [illegible] improved shuttle, a casing or tube of some elastic substance is employed to [illegible] round the bobbin, shown by dotted lines: this tube has an opening [illegible] side, for the wire to pass through; and by closely embracing the [illegible] [illegible] the coil of wire from unwinding, becoming loose, or entangled, [illegible] it to be drawn off evenly and regularly, as it may be required. When [illegible] wire is very stiff and hard, the patentee recommends the employment of a

pair of small steel rollers, to be fixed near the eye-holes, by which means the wire will run out with considerably less friction.

The annexed form of shuttle is adapted to the weaving of fabrics of silk or any other material. It is hollowed out, as described in the former, for the reception of the bobbins, which are three in number; these bobbins being charged with the thread or yarn, may be worked, one after another, with the same coloured thread, or with thread of different colours successively, for weaving

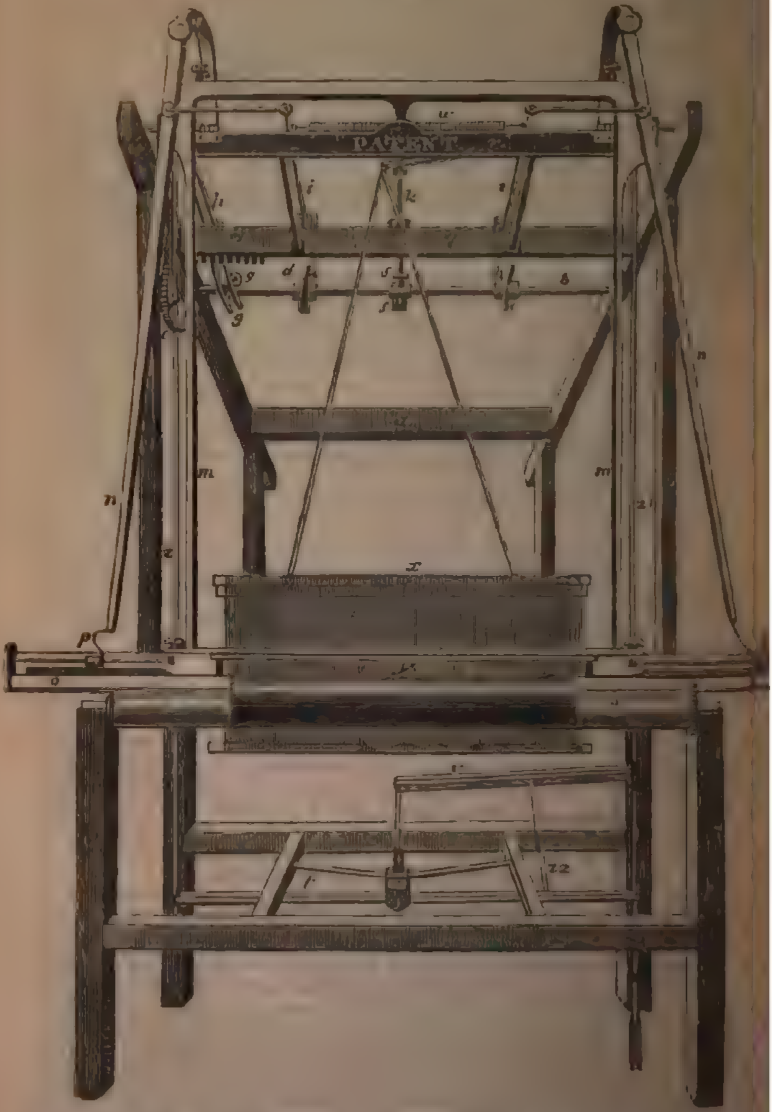
figured goods; and when it is necessary to change the colour, it will only be requisite to break off the end of the weft done with, and draw the end of the other colour through its eye or opening. The springs and screws in this shuttle are similar to those described in the first-mentioned shuttle, and therefore need not be particularized again. Any number of bobbins may be employed in these shuttles, according as the nature of the work may render desirable.

Power-looms, or such as are worked without the intervention of manual labour, were first suggested by Vaucausin, in 1747, but the subject was neglected until the year 1784, when the idea occurred to the Rev. Edmund Cartwright, of *weaving* by power, in consequence, it appears, of the success of Awkwright in *spinning* by power. He commenced the construction of a loom, which, although a very clumsy machine, satisfied him of the practical efficiency of the principle; and accordingly he took a patent for his invention, in 1785, and subsequently he obtained a series of fresh patents for succesive improvements upon the original plan. At length, in 1790, the first manufactory with power-looms was established at Doncaster, in Yorkshire, which was worked by a steam-engine; and in it were made muslins, calicoes, and other fabrics, equal to those made by hand-looms. Shortly afterwards, a Mr. Grimshaw attempted the introduction of Cartwright's power-looms into Manchester; a large factory was erected, and partly furnished with the machinery, when the whole was burnt to the ground, supposed to be the act of incendiaries. This circumstance deterred other manufacturers from adopting power-looms, for a considerable time; and the prosecution of this important invention was probably in a great measure delayed by the indifference manifested by Mr. Cartwright himself to the matter, owing to his mind having become absorbed in other inventions, from which he expected more gratifying results. These obstacles, which beset the invention of the power-loom at the early stage of its introduction, were by degrees surmounted, and manufacturers vied with each other in effecting and maturing improvements in its details, which became the subjects of very numerous patents. A faithful description of only the meritorious portion of the mechanical combinations and curious movements that the power-loom has been the cause of bringing into operation, would alone fill a large volume. In making a selection, therefore, of one or two of those inventions for illustration, the reader must not consider them as detracting from the merits of others, as there are many of equal intrinsic worth.

The first power-loom we shall describe was patented by Mr. Kendall, of Paternoster-row, in the year 1825: our attention was drawn to the subject of it by the following notice of the invention in the *Times* newspaper, on the 24th of June, 1836. "This loom," the editor observes, "is effectual and simple: a boy of twelve years of age, with a proper fly-wheel, would find no difficulty in turning six or eight of them. The number of looms one weaver is capable of working, must depend on two principal objects. The quality of the goods manufactured, and the quality of the materials made use of, varying from two to five looms, such as persians, sarcenets, levantines, and poor satins, which, with good materials, require little attention. Rich works, with an able weaver, and good materials, will be able to work two looms, with an addition of some light work before mentioned. The work is, of course, better than that performed according to the old plan, by hand,—the machine acting more steadily, and operating with less of stickings." Having called upon the patentee, in conse-

quence of the foregoing remarks, he very politely afforded us demonstrati[ve] proofs of the correctness of the foregoing statement, by allowing us to turn [the] winch, by which two looms were put into operation, and we wove the [...] portion of two very rich figured silks, with so much ease as to require [the]

Fig. 1.



application of only one hand. Viewing the loom distinctly from the pow[er] applied, it is in all respects of the same construction, and operates exactly the same as the common hand-loom; and every description of fabrics can [...]

be woven by it: herein consists one of its chief excellencies; for a who has never seen a power-loom in his life, may at once proceed, any instruction, to arrange the several matters preparatory to the act of , in the manner he has been accustomed; and afterwards see all the d and successive movements in weaving executed with the utmost .

in the foregoing engraving exhibits a front view of Kendall's power- which all the principal parts may be seen: *a a a* is the framing, *b* is a g shaft or bar, which is put in motion by the action of a pinion, (par- y shown by *Fig.* 3,) taking into the spur-wheel *c*; *d* and *e* are two cams t upon the levers *i i*, the same being connected to the spiral spring *w*, motion to the shuttle. *f f* are two wipers, which operate on the batton . *g g* are two other wipers, acting upon the two treadle levers *h*. *l l* are blers, which raise and depress the harness. *m m* are the swords of the . *n n* are two vertical rods in connexion with the shuttle. *o o* is the huttle-race. *p p* are the drivers sliding upon horizontal wires, which ately propel the shuttle. *q* is an iron bar, carrying various levers as entioned. *r* is the front bar, supporting the brackets which carry the rods. *s* is the breast-roll. *t*, the long marches. *v*, the short marches.

Fig. 3.

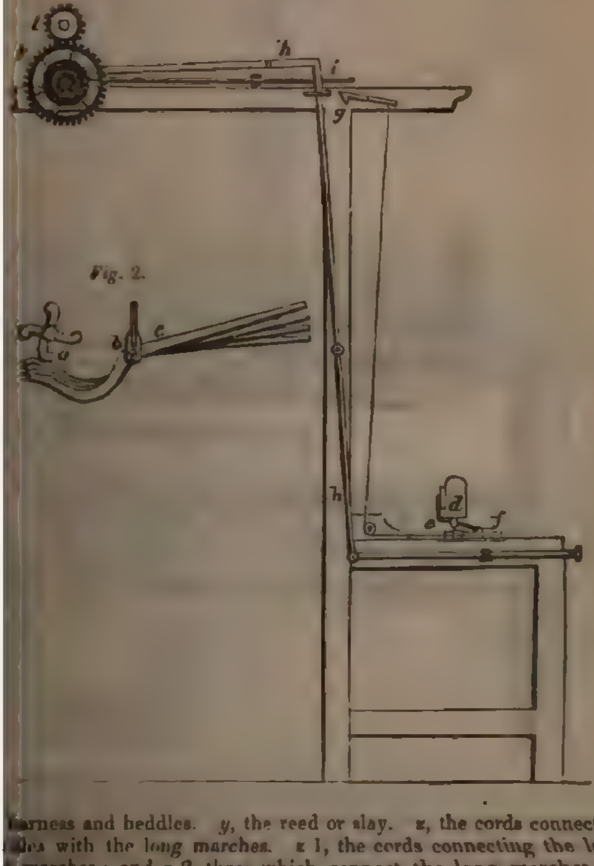


Fig. 2.

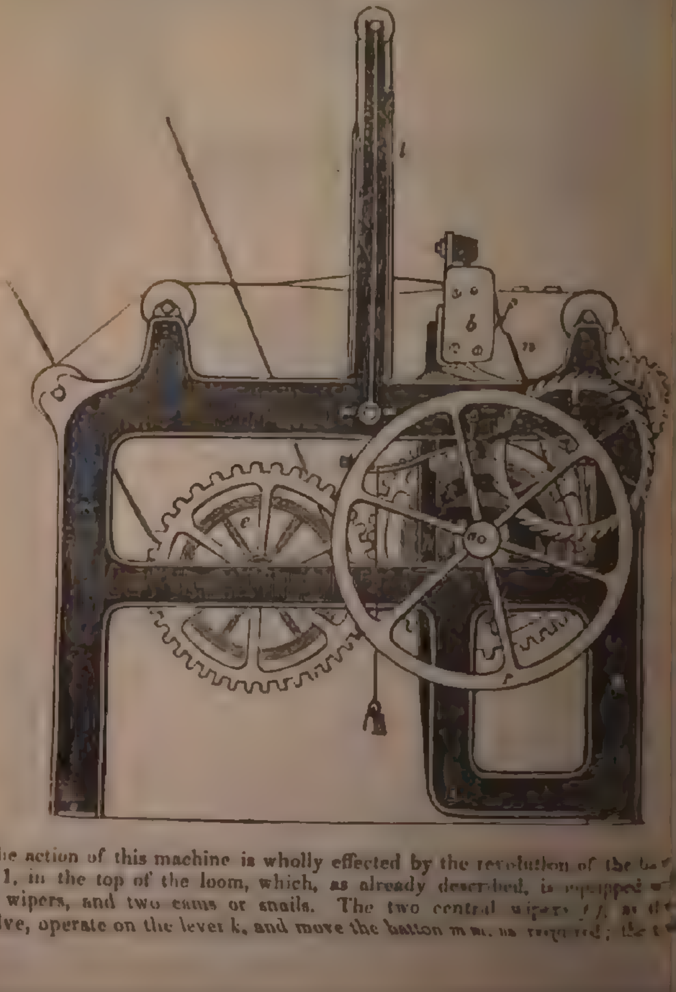
arness and heddles. *y*, the reed or slay. *z*, the cords connecting the les with the long marches. *z* 1, the cords connecting the long with marches; and *z* 2, those which connect the long marches with the

tumblers. The several small spiral springs represented, are for the purpo[se of] giving steadiness, and the necessary tension to the parts, with which the[y are] connected.

Fig. 2 represents a series of treadles, (which may consist of any numbe[r] required,) with the end view of an additional bar, which it is necessary to [intro]duce, when the weaving is of such a nature as to require the operation of [more] than two treadles: in *Fig.* 1 is shown a series of notches or bearings for [the] treadles, (marked 2 upon the bar *g*;) this bar in *Fig.* 2 is shown equipped [with] four wipers *a*, which act successively upon the four treadles *c* beneath.

The intention of the diagram *Fig.* 3 is to show the method adopted b[y the] patentee, for throwing the revolving shaft in and out of gear, and likew[ise to] exhibit the mode by which the power is applied. *d* is the box of the batton[; *e*] is a small bent lever, attached to the box. *f* is a sliding-bolt connected [to a] latch *g*, by a cord. *h h* is a long right-angled lever, furnished at the extre[mity] with an inclined plane, for the purpose of putting the wheel in and out of [gear]. *i* is the lever connected with the clutch, and is operated upon by the leve[r]

Fig. 4.



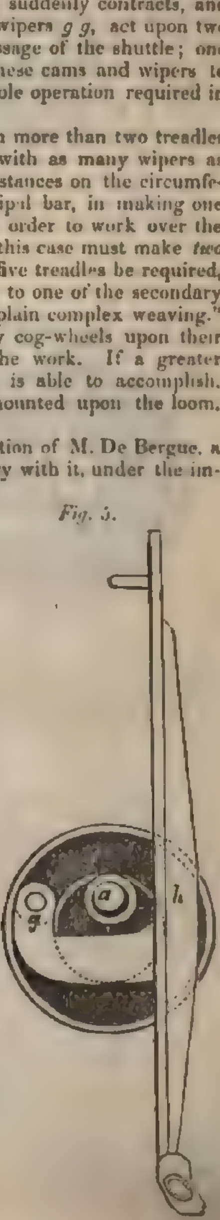
The action of this machine is wholly effected by the revolution of the ba[r,] *Fig.* 1, in the top of the loom, which, as already described, is equipped w[ith] four wipers, and two cams or snails. The two central wipers *f f*, as the[y] revolve, operate on the lever k, and move the batton m m, as required; the t[wo]

tely on a lever each, *i i*; the reverse ends of
ertical rods *n n*, suspended from a bracket *m*
are likewise connected by a spiral spring *w*,
necessary periods may cause the springs to
levers in traversing the cams meet with a
e distended spring suddenly contracts, and
. The other two wipers *g g*, act upon two
pening for the passage of the shuttle; one
o shoots, causing these cams and wipers to
to perform the whole operation required in

plex weaving, when more than two treadles
oduced, equipped with as many wipers as
placed at equal distances on the circumfe-
ssary, as the principal bar, in making one
wice; therefore, in order to work over the
e principal bar in this case must make *two*
econdary bar. If five treadles be required,
l a half revolutions to one of the secondary
treadles used in "plain complex weaving."
rs are regulated by cog-wheels upon their
to the nature of the work. If a greater
an the hand-loom is able to accomplish,
of the jacquard, mounted upon the loom.
aving."

scribe, is the invention of M. De Bergue, a
came to this country with it, under the im-
, not previously
British mecha-
n several of his
e of originality
n we have also
t work, and can
a very efficient
preceding page,
of the machine,
ined and follow-
ction. *a* is the
f which all the
eously or suc-
of this shaft is
the lay, which
ans of a band or
ing over drum-
at *e*, and the
akes it a *power-*
es a spur-wheel,
a, and its rota-
f, fixed at each
This motion is
ig. 5, where the
f the eccentric
path or race *f*
bent arm to a
which is fixed
ns upon a centre
me of the loom;
causes the lever
that very steady
s good weaving.

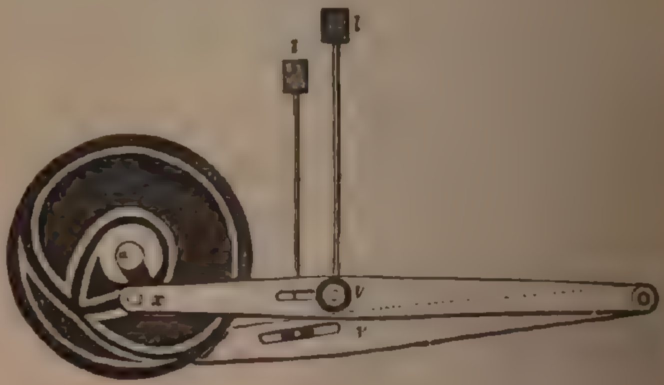
Fig. 5.



In the middle of the shaft *a*, is a broad wheel, (not shown,) in the periphery of which are made two deep grooves, so inclined to each other as to cross in the middle, like the letter X: in these grooves a projecting pin from the shuttle-rod works, so that, by the revolution of the wheel, the said pin traverses the X groove from side to side, and the shuttle-rod, turning upon a fulcrum just above it, is thrown from side to side alternately; and the upper end of the said rod being connected by cords to drivers which slide upon a polished wire, fixed in a channel of the lay. The shuttle is impelled backwards and forwards through the warp by means of the treadles, which are worked by a peculiar eccentric movement, as will be explained by reference to the annexed *Fig.* 6.

At *l l*, the ends of the levers, (seen in section,) are connected to the horizontal levers *v v*, (answering to the treadles of the common loom,) which turn

Fig. 6.



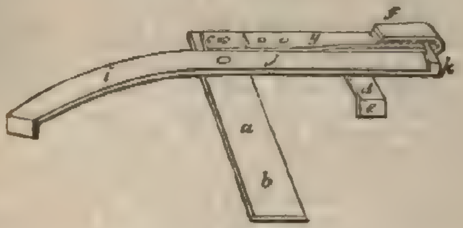
upon a joint at the back of the looms. The other ends of the levers are furnished with steel pins *x*, which work in two eccentrics having the peculiarly shaped grooves delineated in the figure, as the said eccentrics revolve upon their central axis *a*; the revolution of these eccentrics, it will be perceived, causes the steel pins alternately to traverse along the external groove, and then the internal heart-shaped groove, which produces that peculiar vibration in the bars *v v*, and the required reciprocation of the lames *l l*, to open the threads of the warp after each successive shoot. The reed or cane, which is the immediate instrument for beating up the threads of the woof, is situated in the lay or batton. The cloth as it is woven passes over the breast-beam, and winds itself on the roller, which receives its motion by a toothed wheel fixed upon it, and a pinion upon the same axis as the ratchet-wheel.

In a lecture delivered by Dr. Birkbeck, at the London Mechanics' Institution, on the subject of weaving, this loom was publicly worked, when it was found to weave at the rate of a yard and a quarter per hour of gros de Naples.

Some successful attempts have recently been made to produce a figured or rather variegated pattern in silks by plain weaving. It is effected by composing the weft or woof of two different coloured threads twisted together; which may be of silk, of silk and worsted, or of linen, cotton, and silk, variously combined. The more the colours are contrasted, the more brilliant, of course, is the effect. Long specks or spots are produced by twisting the threads very slightly, and short or minute ones by a hard twist. The warp of the fabric, as well as the shoot are composed of a similar or different arrangement of threads, and thus by slight variations, a great diversity of pretty patterns may be obtained.

A patent was taken out in 1833 by Mr. W. Graham of Glasgow, for "a

self-acting *temple* to be used in the operation of weaving by power or hand looms," for the purpose of keeping the fabric at the width the reed leaves it. The invention consists in an apparatus affixed near each end of the breast-beam, which, being acted on by the swinging of the lay in beating up the weft, are caused to open and shut, and, by means of these apparatuses, the cloth is held to the width at which the reed leaves it after beating up the weft.



The above is a perspective view of the apparatus. *a*, is a plate which is affixed to the breast-beam of the loom at the slot at *b*, by means of a screw-bolt passing through the breast-beam; and where different widths of fabric are woven in the same loom, the temples must be so constructed as to allow of being brought nearer to, or farther from each other, by means of the slots formed in the plate *a*. On to the plate *a* is fixed, by means of a screw, another plate *c*, having a projection *d*, which is turned down at right angles at *e*, the object of which will be hereafter described. The outer end of the plate *c* is turned over, so as to produce a parallel plate *f*, having a space between them; *g* is a spring affixed to the plate *c*, by rivetting or otherwise, and on the face of this spring is formed teeth or grooves, cut in a line with the direction of the cloth, these teeth or grooves being intended to hold the cloth when the spring is pressing upwards against the plate *f*; *i* is a lever, which has its fulcrum at *j*, on the plate *a*; and at one end of the lever *i* is formed a projecting wedge *k*, which is pressed between the upper plate *f* and the spring *g* every time the lay beats up the weft, by the lay coming in contact with the other end *b* of the lever *i*, this and *l*, being turned down, as shown in the drawing, for that purpose. There is to be one of these apparatuses placed near the breast-beam, that is, in such a position that they shall just embrace the outer edges or selvages of the fabric, between the plate *f* and the spring *g*, and they are so placed as to take hold of the fabric as near as possible to the point at which the reed strikes up the weft; but the reed is prevented being injured by the bottom of the lay coming in contact with the parts *e*, which stops the lay from approaching too near to the temples at the beating up the weft; and at the time the lay has nearly finished its stroke it comes against the part *l* of the lever *i*, which drives the wedges *k* between the plates *f* and the springs *g*, and causes them to separate to permit the fabric being drawn through them; but immediately on the receding of the lay, after having beaten up the weft, the springs *g* will press up against the plates *f*, and retain the cloth between them, the wedges *k* being forced out by the pressing up of the springs, and by this means the fabric will be kept to the width at which the reed leaves it.

WEDGE. A simple machine, of great utility in cases where an immense pressure and little motion are required. The wedge may be considered a modification of the inclined plane, to which in many cases it is strictly analogous, differing only in the circumstance that the body to be moved is drawn along the surface of the plane; but in the wedge the plane is made to move by percussion beneath the body to be raised, or between the surfaces to be separated. Wedges are frequently employed for splitting masses of timber or stone; ships are raised in docks by wedges driven under their keels. Sometimes they have been employed to restore a declining edifice to the perpendicular position. In

the annexed cut the wedge *a c b* is employed in cleaving wood, and its mechanical power is estimated by the proportion of *a b* to *d c*. This is sometimes differently stated, and it is difficult to state positively what is the exact power obtained by the use of the wedge, as it is generally driven by blows of a mallet or hammer; there can, however, be no doubt that the penetrating power is increased by increasing the length *d c*, in proportion to the breadth *a b*. The wedge, in part, owes its value to a quality which, in most machines, is a diminution of their effect, *i. e.* the friction that arises between it and the substance it divides. Were it not for the immense friction which obtains in the use of the wedge, it would recede to its original position, between the successive blows, and thus no progress would be made. Instead of this, however, we find the pressure and adhesion of the surfaces prevent the recoil, and thus a succession of slight blows effect a result which previously might have been supposed beyond human power to realize. All cutting and piercing instruments, as knives, chisels, razors, nails, pins, &c., may be considered as wedges. The angle of the wedge, in these cases, is more or less acute, according to the purposes to which it is to be applied. The mechanical power of the wedge is of course increased by diminishing the angle, but as this diminishes the strength of the instrument, there is a practical limit to this increase of power. In tools intended for cutting wood the angle is generally about 30°. For iron it is from 50° to 60°; and for brass from 80° to 90°. Tools which act by pressure may be made more acute than those which are drawn by percussion, and in general the softer the substance to be divided, and the less the power required to act upon it, the more acute may be the construction of the wedge.

WEIGHING-MACHINES have been described by us under the article BALANCE, in which article, however, we have omitted a notice of the annexed singular but simple and useful contrivance, the invention of Mr. Hawkins, of Fleet-street. It is called the hydraulic weighing-machine, and is chiefly designed for domestic use. *a*, in the annexed figure, denotes a cylindrical vessel made of tin and japanned, and partly filled with water; *b* is another cylinder of the same kind, but of less diameter, resting upon, or floating in the water contained in *a*; *c* is a graduated scale, with a glass tube running up the middle, fixed to the exterior cylinder; the bottom of this tube opens into the lower part of the cylinder, therefore the water always stands at the same level in both. *e* is a dish or scale, for holding the article to be weighed, the pressure on which causes the internal cylinder to sink lower, and raise the water higher between the two vessels, the level of which is indicated by the tube, and the weight at such level exhibited on the scale. There is of course a liability to change, by a portion of the water evaporating: but, by leaving a weight on the scale when not in use, and pouring in of a small quantity of water occasionally to bring it to the level of the mark on the scale, an adjustment is easily made.

WEIGHT. The force by which bodies in air press towards the centre of the earth; and the measured quantity of that force, in any body, is the weight of it. The earliest attempt on record to define measure of capacity and weight, by referring them to some natural standard, was made in the 51st year of the reign of Henry III., A.D. 1266; it is as follows:—

"An English penny, called a sterling, round and without clipping, shall weigh

thirty-two wheat corns in the midst of the ear, and twenty pence to make an ounce, and twelve ounces one pound, and eight pounds do make a gallon of wine; and eight gallons of wine do make a London bushel, which is the eighth part of a quarter." These weights and measures were again precisely specified and confirmed in the reign of Henry VII., in the year 1496. The first statute that directs the use of the *avoirdupois* weight is the twenty fourth of Henry VIII., wherein it is directed to be used for weighing butchers' meat in the market, though it has been used for weighing all kinds of coarse bulky articles of ordinary consumption. This pound contains 7000 troy grains; while the troy pound contains only 5760 grains. The difference between the troy and avoirdupois weight may be more exactly determined by reference to the annexed tables.

Troy Weight.

				Cubic inches of water.
$\frac{1}{252.458}$ of a cubic inch of water	=	1 grain	=	.0039610571428
24 grains	=	1 pennyweight	=	.0950653714285
20 pennyweights	=	1 ounce	=	1.901307428571
12 ounces	=	1 pound	=	22.815689142857

A cubic inch of distilled water, at the maximum density weighs 253 troy grains.

Avoirdupois Weight.

				Cubic inches of water.
$27\frac{11}{32}$ grains	=	1 dram	=	.10831015625
16 drams	=	1 ounce	=	1.7329625
16 ounces	=	1 pound	=	27.7274
28 pounds	=	1 quarter cwt.	=	776.3672
4 quarters	=	1 cwt.	=	3105.4688
20 cwt.	=	1 ton	=	6210.93760

175 troy pounds = 144 avoirdupois pounds.
175 troy ounces = 192 avoirdupois ounces.

By an act of parliament made in the fifth year of his late majesty George IV., it was enacted that there should be adopted on, and after the 1st of May, 1825, throughout the United Kingdom, a uniformity of weights and measures. The following is, according to Mr. Gutteridge, the rationale of the improvement introduced by this act. "Take a pendulum which vibrates seconds in London, on a level with the sea, in a vacuum; divide all that part thereof which lies between the axis of suspension, and the centre of oscillation, into 391393 equal parts; then will ten thousand of those be an imperial inch, twelve whereof make a foot, and thirty six a yard. Take a cube of one such inch of distilled water, at 62° of temperature, by Fahrenheit's thermometer; let this be weighed by any weight, and let such weight be divided into 252458 equal parts, then will one thousand of such parts be a troy grain; and 7000 of these grains will be a pound avoirdupois, the operation having been performed in air. Ten pounds, such as those mentioned of distilled water, at 62° of temperature, will be a gallon, which gallon will contain 277 cubic inches, and 274 one thousandth parts of another cubic inch." By the authority aforesaid it is also enacted, "that a cubic inch of distilled water in a vacuum, weighed by brass weights, also in a vacuum, at the temperature of 62° of Fahrenheit's thermometer, shall weigh 252.724 grains:" and, "that the standard measure of capacity, as well for liquids as for dry goods not measured with heaped measure, shall be the gallon containing ten pounds avoirdupois weight, of distilled water weighed in air, at the temperature of 62°, the barometer being thirty inches." This gallon, therefore, containing 277.274 cubic inches, is about one-fifth greater than the old wine gallon, one thirty-second greater than the old dry gallon, and one-sixtieth less than the old beer gallon. Eight such imperial gallons to be a bushel, eight such bushels to be a quarter of

corn or other dry goods, the quart to be one-fourth, and the pint one-eighth of the above gallon, and none of these measures to be heaped up. The said standard bushel, which will therefore contain eighty pounds, avoirdupois, of water, is required to be a cylinder with a plain and even bottom, the extreme diameter of which is nineteen and a half inches. No other bushel than this is to be employed for coals, or other commodities usually sold by heaped measure.

WELDING. A term applied to a peculiar process of uniting pieces of iron together by heat and pressure. There are only two metals susceptible of this process, iron and platina. They are brought to a white heat in a furnace, and joined by quick and forcible hammering, by which they unite as one piece, when executed by skilful workmen.

WELD, or WOALD. A plant cultivated in many parts of this kingdom, for its yellow colouring matter. Two sorts of weld are distinguished, the bastard or wild, which grows naturally in the fields; and the cultivated, the stalks of which are smaller and not so high. The latter is preferred for dyeing, abounding more in colouring matter. When the plant has arrived at maturity the stalks are pulled, made into bundles and dried, in which state it is used. To give a permanent yellow to wool by weld, mordants become necessary; but when prepared with alum and tartar, it takes a very durable and fine yellow.

WHALE-FISHERY. This subject being so intimately connected with our manufactures, we insert the following account of it. In the Greenland fishery by Europeans, every ship is provided with six boats, to each of which belong six men, for rowing the boat, and a harpooner, whose business is to strike the whale with his harpoon. Two of these boats are kept constantly on the watch, at some distance from the ship, fastened to pieces of ice, and are relieved by others every four hours. As soon as a whale is perceived, both the boats set out in pursuit of it, and if either of them can come up before the whale finally descends,—which is known by his throwing up his tail,—the harpooner discharges his harpoon at him. As soon as the whale is struck, the men set up one of their oars in the middle of the boat, as a signal to those in the ship; upon which all the others set out to the assistance of the first. The whale, finding himself wounded, swims off with prodigious velocity. Sometimes he descends perpendicularly, and sometimes he goes off horizontally, at a small depth below the surface. The rope which is fastened to the harpoon is about 200 fathoms long, and properly coiled up, that it may be freely given out as there is a demand for it. At first, the velocity with which this rope runs over the side of the boat is so great, that it is wetted to prevent its taking fire: but in a short time the strength of the whale begins to fail, and the fishermen, instead of letting out more rope, strive as much as possible to pull back what has been given already, though they always find themselves necessitated to yield at last to the efforts of the animal, to prevent his sinking their boat. If he runs out the 200 fathoms of line contained in one boat, that belonging to another is immediately fastened to the end of the first, and so on; and there have been instances where all the rope belonging to the six boats has been necessary, though half that quantity is seldom required. The whale cannot stay long below water, but again comes up to blow; and, being now much fatigued and wounded, stays longer above water than usual. This gives another boat time to come up with him, and he is again struck with a harpoon. He again descends, but with less force than before; and when he comes up again, is generally incapable of descending, but suffers himself to be wounded and killed with long lances which the men are provided with for that purpose. He is known to be near death when he spouts up the water, deeply tinged with blood. The whale, when dead, is lashed alongside the ship. They then lay it on one side, and put two ropes, one at the head and the other at the place of the tail, which, together with the fins, is struck off, as soon as he is taken, to keep those extremities above water. On the off-side of the whale are two boats, to receive the pieces of fat, utensils, and men, that might otherwise fall into the water on that side. These precautions being taken, three men with irons at their feet, to prevent slipping, get on the whale, and begin to cut out pieces of about three feet thick and eight long, which are hauled up at the capstan or windlass. When the fat is all got off,

they cut off the whalebone of the upper jaw with an axe. Before they cut, they are all lashed to keep them firm; which also facilitates the cutting, and prevents them from falling into the sea; when on board, five or six of them are bundled together and properly stowed, and after all is got off, the carcase is turned adrift, and devoured by the white bears, who are very fond of it. In proportion as the large pieces of fat are cut off, the rest of the crew are employed in slicing them smaller, and picking out all the lean. When this is prepared, they stow it in under the deck, where it lies till the fat of all the whales taken during the fishery is on board; then cutting it still smaller, they put it up in tubs in the hold. At the end of the season they return home, where the fat is boiled and pressed, to give out the oil. (See a press for this purpose, under the Article OIL.)

Among the Kurile islands, which are situated near the southern extremity of the peninsula of Kamtschatka, the whales are most abundant about the beginning of autumn. At that time the inhabitants embark in their canoes, and search for them in places where they generally find them asleep on the surface of the water. When they are so fortunate as to find one in this situation, they approach with the least possible noise, and when they have come within the proper distance, they pierce him with poisoned arrows; and although these wounds seem extremely slight, they are said in a short time to occasion great pain. The whale thus wounded, moves about furiously, blows with great violence, and soon dies.

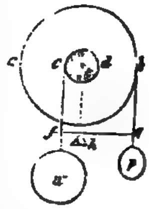
When the whale returns to Greenland, the fishermen equip themselves with sharp knives, harpoons, spears, and arrows, with a number of large skins of the sea-dog, inflated. Thus equipped, they launch their canoes. The harpoon which they usually employ is pointed with bone, or a sharp stone; some, indeed, have harpoons of iron, which they procure from the Danes, by barter for the oil or fat of the whale. The scarcity of iron and wood makes these articles extremely valuable to Greenlanders, and has excited their ingenuity, to avoid the risk of losing them. For this purpose an inflated bladder of dog's skin is attached to the harpoon; so that, in case it should not reach the whale, when they attempt to strike, it may float on the water and be recovered. They approach them with astonishing boldness, and endeavour to fix, by means of their harpoons, which they throw at his body, some of the skins inflated with air; for, notwithstanding the enormous bulk of this animal, two or three of these skins, by the resistance which they make to the water, on account of their diminished specific gravity, greatly impede his attempts at plunging into the deep. Having by this means succeeded in arresting his progress, they approach nearer, and with their lances pierce his body, till he becomes languid and at last dies. The fishermen then plunge into the sea with their skin jackets filled with air, and swim to their prize; and, floating on the surface of the water, they cut off with their knives, from every part of the whale, the fat or blubber, which is thrown into the canoes; and notwithstanding the rudeness of their instruments, their dexterity is such, that they can extract from the mouth the greatest part of the whalebone.

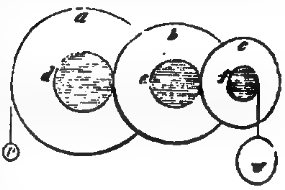
The boldest and most astonishing mode of fishing the whale, is that which is practised by the Indians on the coast of Florida. When the whale appears, they fasten to their bodies two pieces of wood and a mallet; and these instruments, with their canoe, form the whole of their fishing equipage. When they approach the whale they throw themselves into the water, and, swimming directly towards him, they have the address to get on his neck, taking care to avoid the stroke of his fin or tail. When the whale first spouts, the Indian introduces one of the pieces of wood into the opening of one of the blow-holes, and drives it home with the mallet. The whale thus attacked, instantly plunges, and carries the Indian with him, who keeps fast hold of the animal; the whale, which has now only one blow-hole, soon returns to the surface of the water to respire; and if the Indian succeeds in fixing the other piece of wood into the second blow-hole, the whale again descends to the bottom, but a moment after reappears on the surface, where he remains motionless, and immediately expires, by the interruption of the function of respiration.

WHARF. A firm landing-place, built beside the water for the convenience of loading or unloading ships, barges, or other vessels; and therefore usually

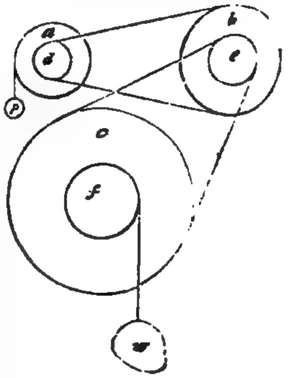
furnished with cranes and various appendages, according to the nature and extent of the business to be performed.

WHEEL and AXLE. A modification of the lever, by means of which a weight may be raised to a considerable height. A slight attention to the nature of the lever will show that the extent of its influence in space is very small, depending upon the length of that arm to which the weight is attached; and as this arm becomes shorter in proportion to the increase of power obtained, so the height to which a body may be raised, speedily attains its limit. In the wheel and axle, no limit of this kind exists. Let *a b*, in the annexed cut, represent the diameter of the wheel, and *c d* that of the axle; then, if a power *p* be connected by means of a rope to the wheel, and a weight *w* to the axle, these two, when in equilibrio, will be to each other as *c d* to *a b*. That is, *the power is to the weight as the diameter of the axle to the diameter of the wheel;* or, since the diameter of a circle is double its radius; as, *the radius of the axle to the radius of the wheel.* If a line *f h g* be drawn, connecting the parallel cords, and a perpendicular *e h* be let fall on it, it will be divided in the same ratio as the diameters or radii of the wheel and axle; and hence its relation to the lever becomes manifest. It will be immediately seen that the power is to the weight, as *f h* to *h g;* that is, as the radius of the axle to the radius of the wheel. The velocity with which the power and weight will move, is, as in the other simple machines, inversely as the power gained. If the diameter of the wheel be 20 inches, and that of the axle 4 inches, the power obtained will be $\frac{20}{4} = 5$ times; or a power of one pound will balance a weight of five pounds; but the velocity with which the weight moves, is five times less than that of the power. The windlass by which water is drawn from wells, and the capstan used to raise the anchor on ship-board, are illustrations of the utility of this simple machine; but the most extensive employment of the wheel and axle is in combination, in which, under the name of wheel and pinion, it enters largely into the construction of the most complicated machinery. In the arrangement of a number of wheels and pinions for the purpose of gaining power, or velocity, each pinion is connected with the following wheel, and the power or weight is attached to the last pinion.





Thus, in the foregoing representation *a b* and *c* are three wheels; *d e f*, three axles or pinions, as it may be; the power *p* puts *a* into motion, the axle of which turns *b*, whose axle again influences *c*, on the axle of which the resistance is applied. The proportion between *p* and *w* in this and similar cases, will be found by multiplying together the diameters of the axles, and the diameters of the wheels. If the diameters of the wheels be 14, 9 and 7, and the axles be 3, 3 and 2, the power obtained will be $\frac{14 \times 9 \times 7}{3 \times 3 \times 2} = 49$, and as a consequence, the velocity of *p* must be 49 times greater than that of *w*. When wheels and pinions act upon each other as in watches and other machines, a number of teeth are cut in the circumference of each, in nearly the same proportion as the radii of the wheel and pinion. Sometimes, especially in heavy machinery, they are connected by bands, as in the annexed cut; but the calculated power is still the same at whatever angle they may be placed to each other, since the bands always act on that part of the wheel which



is perpendicular to their own direction. In calculating the power of this machine, allowance must be made for the friction on the pivots, the weight and stiffness of the rope, and for the increased magnitude which a large rope gives to the wheel or axle.

WHEEL. A circular frame, or solid disc, made of wood or metal, and turning upon an axis. There are a variety of kinds, but we shall in this place direct our attention to carriage wheels, to which the foregoing definition will best apply. The ordinary carriage wheel consists of three principal parts; namely, the nave, hub, or centre; the spokes or radii, which connect the centre to the periphery or ring. The ring is sometimes made of one entire length, bent into the circular form; but by far the most usual plan is to construct the ring of a series of curved pieces, correctly jointed endways, so as to complete the entire circle. After the ring is thus prepared, and every joint corrected and smoothed whilst placed in its true circle, the joints are bored, and an oaken dowel or pin driven into the perforations. The manufacture of the spokes consists in chopping them first to nearly their shape, and then finishing their figure by spoke-shaves; afterwards they are all gauged to an exact length, their shoulders and tenons made, the tenons that are to enter the stock being square, and those for the felloes round; and all the tenons are made a little larger towards their shoulders than at their other ends, in order that they may fit very tightly when driven up into their mortises. The tenons in the nave depend wholly for their firmness there, to accurate workmanship; but the tenons in the felloes go through their thickness, and are then wedged up on the outside. The strength of a wheel depends greatly on the attention paid to the arrangement and framing of the spokes; in common wheels they are framed equally all round the thickest part of the nave, the tenons of the spokes being so beveled as to stand, with reference to the horizontal position of the nave, about three inches out of the perpendicular: this is done to produce what is called the *dishing* of the wheel. But for obtaining increased strength, the spokes of wheels, (as in those of the mail coaches,) are framed so that every other spoke shall stand perpendicular to the nave. Hence the mortices are made in two parallel lines around the nave, the other ends of the spokes entering the felloes in a single line; therefore, viewed edgeways, the position of the spokes represents two sides of an isosceles triangle, of which the axis forms the base line, (an arrangement which the uninformed will clearly understand, upon reference to the perspective figure of Jones's patent suspension wheel, given further on in this article;) this confers great stability to the wheel, at a trifling addition of cost of workmanship.

The blocks which form the naves of wheels are furnished to the wheelwright, of the size required. The wood preferred for this purpose is elm. To produce their round conical form they are turned in a lathe, with neat mouldings upon the surface. The nave is now ready to have its mortises cut; which is a work of considerable art, especially when executed in the rapid and correct manner in which they usually are, by practised workmen. In this work the wheelwright uses a very simple and efficient tool, that is peculiar to his craft; it is called a *buz*, and is employed to cut out the angles of his mortises square and clean; it is a sort of double chisel, or that in which the straight edges of two common chisels are united at right angles; and it cuts out the corners, as may be supposed, very expeditiously, and so exactly that the square tenon of the spoke bites very firmly in every part. The workman fits each spoke successively, and puts a mark upon it. When they are all fitted, he begins to put the whole wheel together, fitting all the spokes to the nave first, and then adding the felloes. In this state the wheel is put to season; that is, exposing it to a current of air for a week or two, or, as in some manufactories, placing it in a kiln for a few hours, heated to about 140° Fahrenheit. When seasoned, the whole of the wheel is examined, to ascertain if all its parts are still adapted to make solid and close joints in every part; and if found so, they are all secured and fixed, by driving up all the spokes firmly into the nave, and then putting on the felloes, and driving them down firmly upon the shoulders of the spokes; and the ends of the tenons, which come through the felloes, are then secured by

wedges driven into their middles. This done, the wheelwright "cleans off," that is, finishes the wood-work, by his planes, shaves, fish-skin, and glass-paper. The next operation is to put on the iron tire. The tire is made of flat bar iron and of breadth and thickness proportioned to the wheel. When the tire consists of separate pieces or streaks, the bars are cut to the same length as the felloes, and curved to the radius of the wheel, and have suitable holes punched through them, to receive very stout nails, by which they are secured to the wooden ring of the wheel; and the iron tire is so placed over the felloes, as to meet in the middle of each felloe, and thus secure more effectually the joints of the latter; the tire nails pass quite through the felloes, and are rivetted on the inside of the ring, upon bars or washers, which materially strengthens the fabric. Further to bind and compress the parts of the wheel together, the tire is put and nailed on to the wheel in a red-hot state; which burns and presses down all bumps and inequalities of the surface, and produces great solidity of structure. The best kinds of wheels,—those used for coaches and other light vehicles,—have usually their tires of one single piece or ring ready formed, which is expanded by being made hot in a circular fire, and in this state put upon the wooden periphery of the wheel, when, by its shrinking as it cools, it draws all the parts of the wheel together with irresistible force.

Many years ago a patent was obtained for making the whole wooden periphery of one entire piece, and this process is still extensively practised for the wheels of light carriages. Straight grained ash is selected and boiled or steamed, until it becomes very flexible, when it is bent on a cylinder, and fastened together whilst in its circular form.

Having now described the several parts of an ordinary carriage wheel, excepting the axletree, and box, we refer the reader for information on those points to their initial letter (also to the articles Carriage and Railway,) in this work, and proceed to the description of some modern improvements.

The purposes to which iron, whether cast or malleable, may be usefully applied, are daily becoming more numerous; its great durability, and the facility with which it may now (by the aid of our varied and powerful machinery, be wrought to any desired form, point it out as peculiarly adapted for the wheels of

Fig. 1.

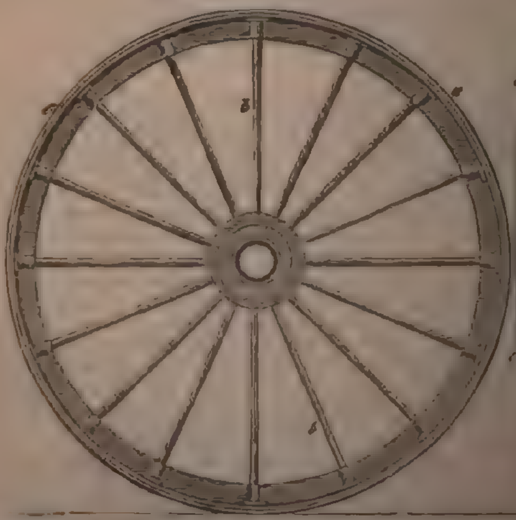
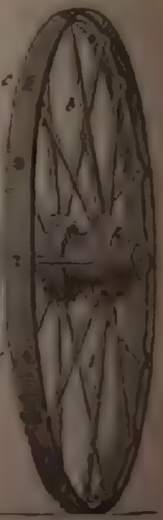


Fig. 2.



carriages. Accordingly, various attempts have been made at different times to construct wheels wholly of this material, but certain difficulties have opposed

their general introduction; and their use may be said to have been confined to rail-roads, until the invention of Mr. Theodore Jones, who took out a patent for an "iron suspension-wheel," about eight years ago, and a large manufactory of them has been established at Vauxhall, from whence are constantly sent out considerable numbers, attached to the carts and waggons of the metropolis, as our London readers will testify, upon recognizing their representation in the above engravings, of which *Fig.* 1 is an elevation, and *Fig.* 2 a perspective view of a cart or light waggon-wheel, the principle of their construction not differing according to

Fig. 3.

Fig. 4.

their application, but only in the proportions of their parts. *Fig.* 3 represents a nave, shown on a larger scale, with the front shield or cap removed to show the construction. It contains eight feathers or divisions, dividing it into eight compartments. *Fig.* 4 is a section of the nave, with the front and back shields in their places.

At *a* is a strong rim of cast or wrought iron, with a rib on the inside to give additional strength. Sixteen conical holes are made through the rim at equal distances; *b b b* are wrought iron rods, with conical heads *c c c* fitting into the holes of the rim, and have screws cut at their other ends. These rods, through the holes in the rims, and corresponding holes in the nave, where the screwed ends are secured by nuts, are plainly shown in the sections. The shields are then placed over the nave, and by the pressure of their flat surfaces against the sides of the nuts, they are prevented from becoming unscrewed. A hoop or iron tire is fixed on the outer circumference which is to be replaced when it becomes worn by use.

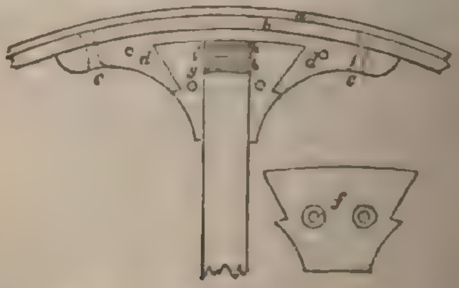
The description we have thus given is derived from the specification of the patentee; but since the enrolment of that document, the experience of the inventor, derived from great practice, has enabled him to introduce many subordinate improvements, amongst which we may mention, the making the rim, with the projecting rib underneath, of one single solid piece of wrought iron, obviating the use of any cast iron, and dispensing entirely with the necessity of any tire ring. This is a very important improvement, as it was discovered that the battering which the tire rings received against the stone pavement, had the effect of expanding them, and consequently of causing them to separate or become loose upon the iron periphery underneath; and when the latter was of cast-iron, fractures were sometimes made by the concussions of the road. Now, as there is only one ring, and that of wrought iron, the expansion that it may undergo by severe battering, has only a tendency to increase the tension of the rods, and the stability of the whole.

It will be observed in the drawings that the wheels are not conical, nor dished as usual, but cylindrical; which, in the opinion generally of those who have been enabled to examine the subject, unprejudiced, causes them to move with less resistance *on their peripheries*, or *run lighter*, as the phrase is; and they

will, from the same cause, prove less destructive to the road. This latter property may be considered as established, as an act of parliament empowers the trustees of the roads to reduce the tolls on the cylindrical wheels, to two thirds of the sum paid for conical wheels of similar width. The reason of these patent wheels being called *suspension* wheels, is that the nave may be considered as constantly suspended by the rods above it to an inflexible arch; instead of, as in the common wooden wheels, resting with its load upon the particular spoke that may happen to be underneath it; and thus it is argued the cohesive strength of the metal is made available, which is undoubtedly the most advantageous mode of employing malleable iron, (it having been proved by repeated experiments, that a rod of wrought iron, an inch in diameter, is capable of sustaining a pull of twenty-seven tons weight;) and the weight of the load upon the axles being thus suspended to the upper side of the wheel, the lower rods have to sustain but a small portion of the pressure, and are not liable to be broken by sudden concussions or jolts. From the superior tenacity of the metal over wood, the mass of material is so considerably reduced, as to render a suspension wheel not heavier than a wooden one, which is applicable to the same kind of carriage or strain; and from the circumstance of this diminution of material they have a more elegant and light appearance, require less draught, whilst they unquestionably possess increased strength and durability.

However excellent may be the workmanship, or however firmly an ordinary wooden wheel may be put together in the first instance, the wooden felloes that form the periphery, being constantly exposed to the effects of wet and dry, are continually expanding and contracting; consequently the joint or connexions between the ends of the spokes and the felloes, and the former, either become loose, or split the felloes; when this takes place, the several parts of the wheel yield by little and little to the strain of the load, or the effects of concussions, and the whole wheel becomes dislocated. As a remedy to this defect, Mr. Wm. Howard, the ——— master of Rotherhithe, has recently proposed some new arrangements of a precisely opposite character to Mr. Jones's; which we proceed to describe.

Mr. Howard's invention has no reference whatever to the nave of the wheel, but is confined to an improved mode of combining a wheel at its periphery. He employs, as shown in the subjoined figure, representative of a small portion of a wheel, an iron ring *a*, as the outside tire; inside of this tire he has another ring of iron, *b*, which stands as a substitute for the ordinary felloes; and to this, which we will call for distinction the felloe-ring, he fastens by red-hot rivets *c c*, a "spoke-shoe" *d d*, made of the shape represented, of cast-iron, and containing a central cavity or socket, for the insertion of the end of a spoke *e*; of course there are as many spoke-shoes as spokes, which are arranged equidistantly around the inside of the felloe-ring; when these have been all firmly fixed in



the manner of that shown, and the spokes have been all duly fitted into the nave and driven home, and the outer ends of all the spokes have been accurately gauged, and duly fitted to the sockets of the shoes, they are put or forced into the same sideways, as seen at *e*; this operation is performed in such a manner as to leave a space of about half an inch between the ends of the spokes and the

ends of the sockets, for the purpose of wedging them up firmly. This is effected in the following manner:—Against the squared end of each spoke is laid a thin piece of plate-iron *g*, of the same sectional area; then is driven a slightly tapered long oaken wedge *h h*, the foremost end passing through a hole cast in the shoe on the opposite side: and when the cavity is thus closely filled, the projecting pieces are cut off, and a sharp iron wedge *i*, is then driven into the middle of the oaken wedge, so as to render the force of contact as great as possible; a plate of wrought iron, *f*, is then put into the cavity represented over *e h i*, and riveted to the shoe by long red-hot rivets passing through the whole. All the shoes and spokes being thus fitted, the tire ring is put over the whole in a red-hot state, which, shrinking as it cools, draws the whole together in a manner that gives it extraordinary solidity.

It will be observed that the principle of construction of Mr. Howard's wheels is the same as that of the common kind, in which dependence is placed entirely upon the stability of the outer ring for its cohesion; but it is a more finished and masterly production, is constructed of more tenacious materials, and is well calculated to obviate the leading defects before mentioned of the former. The advocates for Mr. Jones's wheel object to Mr. Howard's, on the ground of its not being on the tension principle. On this point we would observe, that the spokes undoubtedly are not, but that it may be fairly contended that the periphery is, as this must be torn asunder by a longitudinal pull, in order to destroy the cohesion of the wheel; and the felloe-ring alone, (which never wears,) is made of adequate strength to bear the whole strain, without any of the additional support it derives from the tire-ring; the utmost confidence may therefore be placed in the great strength and durability of Mr. Howard's wheels, however excellent may be the principle of the former invention.

A patent was recently taken out for a very strong metallic wheel, by the Messrs. Forrester, of Liverpool, consisting of a skeleton of malleable iron, imbedded or surrounded with cast iron. Such wheels are, however, necessarily very heavy, and less suited to the common road than to RAILWAYS.—For a description of them, see the latter article.

We shall, however, advert in this place to another patent,—not on account of any novelty it may be found to contain, but for the twofold purpose of elucidating a process that we had imagined was commonly practised by iron-masters and tire-smiths, and of affording us an opportunity of noticing the erroneous principle upon which wheels in general are constructed.

The specification of Mr. John Meaden, of Southampton's patent, (enrolled June 1828,) states his object to be the construction of the tire or hoops of iron, which surround carriage wheels, *concave* on the inner surface, next to the felloes, and *convex* on the external surface; the objects of which are to fix the tire more securely to the wheel, and to reduce the friction produced between the periphery of the wheel and the road. The specification proceeds to describe very minutely the process of making tires,—a process which we doubt not our readers of the before-mentioned callings will recognise as a "modern antique." A common flat wrought-iron bar, of the proper width and length, is to be passed between a pair of rollers, one of which has a concave groove, and the other a corresponding convex projection, so as to compress and bend the intervening bar into the required form. The bar thus formed is next bent round into a hoop of the required size, with the concave side inwards, and then the ends are welded together. To give the hoop the desired conical figure, or "dishing," it is placed over a large cast-iron mandril, like that represented in the annexed figure, where it is hammered until it takes the required form. The letters *a* and *b* indicate hoops of different sizes. To fix this hoop to the wheel, it is heated in a furnace of a circular form, so that the fire may act uniformly on every part. In a large wheel, this process of heating the hoop causes it to expand about one inch in circumference, and it is thereby made large enough to slip over the wooden

wheel previously prepared, of greater dimensions than the interior circle of the iron hoop, in the cold state. When the iron hoop is being heated, the wooden wheel is clamped to a flat circular plate, which is fixed to a central axis, to enable it to revolve; and this axis is fixed upon an horizontal bar, by which the wheel and iron plate to which it is clamped may be turned in either a vertical or horizontal direction. Underneath the circular plate is a suitable well or cistern, containing cold water, into which the wheel is immersed and turned round as soon as the hoop is put on it. This application of cold to the hot expanded hoop causes it to contract with irresistible force, pressing the spokes into the felloes and nave, and binding all the parts together. The annexed little figure exhibits a section of the new patent tire, as applied to the felloe *d*; *e* representing the end of a spoke. A curved tire like the foregoing was made many years prior to Mr. Meaden's patent, but by simpler and cheaper means,—it being rolled directly from the bloom into curved bars; and we think we remember seeing them on the mail coaches more than twenty years ago. The curve on the interior side of the tire is of unquestionable advantage, in causing it to hold more securely on the felloes,—as must be evident from the preceding figure; but the external curvature of the tire is, in our opinion, of very doubtful utility. The rounding of the extreme edges of a flat-bearing wheel may prevent dirt being hitched up and carried round with the wheel; but even that much being removed, reduces to the same extent the resistance of the ground to the wheel sinking into it; and if the whole bearing surface be rounded, it must evidently penetrate deeper into the ground, and in so doing force the materials of the road sideways. Nevertheless, tire of this construction is, we believe, still employed in our mail coaches. But however injurious to the roads may be tire of this kind, the practice of giving a conical form to the rims of carriage wheels is infinitely more destructive. This form has an evident tendency to move in a different direction to the line of draught; and the power which is required to keep it in a straight line is so much power wasted in twisting the materials of the road out of settings, and grinding them to powder.

The cylinder (as Mr. Cumming justly observes) having all its parts of equal diameter, will, in rolling on its rim, have an equal velocity at every part of its circumference, and necessarily advance in a straight line. And as all the parts of the rim have an equal velocity, none can have a tendency to drag forward or impede the progress of the others; they all advance with one consent, without the rubbing of any part on the surface on which they roll. As there is no rubbing there can be no friction, and consequently a cylinder perfectly round, hard, and smooth, forms the least possible resistance, however great its weight or the pressure on its rim. It therefore follows, that all the power that is employed in drawing forward a cylindrical body in a straight line on a compressible substance, is ultimately applied in compressing smooth and levelling the substance on which it rolls. The rolling of a cylindrical body, therefore, can have no tendency to alter the relative situation or parts of materials on which it passes, nor any how to derange them, but by a progressive dead pressure to consolidate, level, and smoothe them. If a cylinder be cut transversely into several lengths, each part will possess all the above properties; and if the rim of a carriage wheel be made exactly of the same shape, it must necessarily have the same tendencies. When wheels with cylindrical rims are connected by an axis, the tendency of each being to advance in a direct line, they proceed in this connected state with the same harmony and unity of consent that exist in the parts of the same cylinder; but, as conical rims have been universally preferred for a series of years, it is natural to suppose that there were obvious reasons for such preference. The cone diminishing gradually from its base to its point, the velocity of every part of its circumference in rolling on an even plane, will be diminished as the diameter; and at the very point where there is no visible diameter, it will have no perceptible motion; but if the cone be made to advance in a straight line, the natural velocity of its several parts will not be as the spaces, therefore a rubbing and friction will take place at its circumference, from the different

velocities of its parts, which must render the draught heavier. In rolling on paved streets nothing can be conceived more calculated for their destruction than the conical rim of a broad wheel. See CARRIAGES, AXLETREE, &c.

For TEETHED WHEELS employed in driving machinery, see that article.

WHERRY. A small, shallow, light boat, made very sharp both at the head and the stern, and adapted for fast rowing and sailing, especially in tide rivers.

WHIRLING-TABLE. An instrument for illustrating the nature of the centripetal and centrifugal forces. The disposition which bodies have to fly off from the axis round which they revolve, may be beautifully exhibited, by employing a small bucket filled with water, and attaching it to the hand by a flexible cord, it may be whirled round without destroying the equilibrium of the fluid, or causing any portion of it to be spilled. Precisely in the same way are the bodies which revolve round the sun, kept from falling into that luminary by the centrifugal force which is generated. Now the whirling-table is employed to exhibit the amount of this force, and, by a combination of weights and pulleys, a variety of bodies are made to revolve with different degrees of speed. The apparatus usually consists of a frame furnished with a large wheel, round which a band passes, and gives motion to two smaller ones. On one of these a rod is attached for balls to slide, and on the other a flat table of mahogany; and these may be put into motion with different degrees of speed. The whole apparatus is exceedingly valuable to the teacher of astronomy.

WHIRLPOOL. An eddy, vortex, or gulf, where the water is continually turning round. Those in rivers are very common, from various accidents, and are usually very trivial, and of little consequence. In the sea they are more rare, but more dangerous. Sibbald has related the effects of a very remarkable marine whirlpool among the Orcades, "which would prove very dangerous to strangers, though it is of no consequence to the people who are used to it. This is not fixed to any particular place, but appears in various parts of the limits of the sea among these islands. Wherever it appears, it is very furious; the boats, &c., would inevitably be drawn in, and be destroyed by it; but the people who navigate them, are prepared for it, and always carry an empty vessel, a log of wood, or large bundle of straw, or some such thing, in the boat with them. As soon as they perceive the whirlpool, they toss this within its vortex, keeping themselves out; this substance, whatever it be, is immediately received into the centre, and carried under water; and, as soon as this is done, the surface of the place, where the whirlpool was, becomes smooth, and they row over it with safety; and in about an hour, they see the vortex begin again in some other place, usually at about a mile distant from the first."

WHIRLWIND. This meteorological phenomenon arises from the convergence of winds from all parts to one point on account of an extraordinary rarefaction of the air at that point. The currents acquire by their conflict at the place of meeting, and the velocity with which the rarefied air rushes upwards, a centrifugal force, which causes them to recede from the axis of rotation. When the centrifugal force thus acquired becomes equal to the pressure of the atmosphere, a space approaching almost to a vacuum surrounds the axis or centre of motion, and as the whirl, by the action of the most prevailing wind, receives a progressive motion, it is obvious that the pressure of the atmosphere will be removed from every object passed over by the base of the vacuum; consequently destruction may be expected to mark its course. Partly by the removal of the atmospheric pressure, and partly by the whirling of the air surrounding the vacuum, loose bodies, a hay-stack, for example, will be raised with irresistible impetuosity, and dissipated at a great height.

WHISKEY. This species of ardent spirit is much used in this country as well as in Ireland. It varies considerably in the mode of preparation as well as in its strength and comparative value. One of the modes of procuring it is stated in Gray's *Operative Chemist* to consist in mixing 3840 gallons of rye or barley ground very fine, and 1280 gallons of coarse ground pale malt, and making it into a mash, with 8500 gallons of water, heated to 170° Fahr. There is then drawn off 1020 gallons of this wort, and a large quantity of yeast is

added to it; and when the remaining wort is cooled to 55° Fahr. eighty gallons of malt are mashed with another portion of 1020 gallons of hot water, and this, being drawn off, is mixed with the first wort, and the yeasted wort is also added. This wash should have the specific gravity from 1.084 to 1.110. In the course of ten or twelve days, the specific gravity gradually diminishes till it becomes only 1.002, when the yeast head falls quite flat; the wash has a vinous smell and taste, and is fit for the still. It is calculated that every sixty-four gallons of meal and malt ought to produce eighteen gallons of spirit, so much stronger than proof spirit that ten gallons will make eleven gallons proof.

In general, one-third of the wash is drawn over at the first stilling, and the product is called low wines, the specific gravity being about 0.975. On re-distilling the low wines, a milky, fiery tasted spirit comes over at first; when the running turns clear, the spirit that has come over is returned into the still. The distillation being continued, the clean spirit comes over; and when the running gets below a certain specific gravity, the remaining spirit which comes over, until it ceases to be inflammable, is kept apart by the name of faints, and is mixed with the next parcel of low wines that are distilled. The proportion of malt to the raw grain is sometimes diminished much below that stated, even as low as only one-tenth of the raw grain. If the wort is not sufficiently heavy, its specific gravity is brought up, by adding a strong infusion of ground malt, or barley and malt. The fermentation is generally carried on in open pits, and hurried as much as possible; but of late some distillers, considering that the carbonic acid gas carried off much of the spirit, have covered the pits with a flooring, having a trap with a water joint, to prevent the loss of the spirit; this retards the fermentation, but the augmentation of the produce, although slight, is judged fully equivalent to the loss of time.

WINCH. The bent, or crank-handle, by which the axes of machines are turned.

WIND. Air put in motion by some physical cause, so as to become a current or stream. Winds are denominated according to the points from which they blow; see COMPASS. A variety of machines have been invented at different times for ascertaining the strength or velocity of the wind; the annexed cut represents one which possesses the advantages of simplicity of construction, and of being unerring in its indications. It is thus formed:—A square open frame of wood or iron, *a b c*, is supported by the shaft *d*; two cross pieces are fixed at *e f*, carrying an horizontal axis, which is moved by the action of the wind upon four sails, *i i i i*, fixed to one end of the axis, and disposed to be influenced by the wind in the usual manner. Upon this axis is also fixed a conical barrel of wood, on the smaller end of which, *n*, is attached a line with a weight, *l*, appended to it. The wind now acting upon the sails, causes the barrel to revolve, and the line to be wound round its superficies. To prevent any retrograde motion, a ratchet

wheel *o*, is fixed to the base or larger end of the cone *m*, having a click [illegible] into its notches as it revolves. It is evident that the force of the wind [illegible] continually increase as the line advances towards the base of the cone, the power being applied at a greater distance from the axis or fulcrum; [illegible] the variable force of the wind may be readily ascertained, by fixing the [illegible] smallest end, and marking the barrel with spiral lines, as taken up by the [illegible]

the rope round its superficies; placing, also, between the line so drawn, numerical signs to denote the force of the wind; which might be calculated with tolerable precision, according to the known principles of the lever. The diameter of the base of the cone should be such, in comparison with the smaller end, that the very strongest wind should have scarcely sufficient power to bring it on to the end of it.

The different velocities, forces, and corresponding popular appellations of winds are given in the following table, derived from the experiments of the late celebrated engineer, John Smeaton; and detailed in the *Philosophical Transactions*

Velocity.		Perp. Force on one square foot in lbs avoirdupois.	Appellations.
Per hour Miles.	Per Second Feet.		
1	1.47	.005	Scarcely perceptible.
2	2.93	.020	Perceptible.
3	4.40	.044	
4	5.87	.079	Gentle breeze.
5	7.33	.123	
10	14.67	.492	Pleasant brisk gale.
15	22.00	1.107	
20	29.34	1.968	Very brisk gale.
25	36.67	3.075	
30	44.01	4.429	High winds.
35	51.34	6.027	
40	58.68	7.873	Very high winds.
45	66.01	9.963	
50	73.35	12.300	A storm or tempest.
60	88.02	17.715	A great storm.
80	117.36	31.490	A hurricane.
100	146.70	49.200	A dreadful hurricane that overturns buildings, trees, &c.

To which may be added a still more remarkable instance of the impetuosity of a hurricane, as related by M. Rochon. The velocity of the wind, as observed by him, was no less than 109 miles an hour, or 159.88 feet per second; and its force against a perpendicular plane of a foot square, was estimated at 58.45 pounds avoirdupois. Of the causes and theory of winds, many very able philosophers have treated largely; as Des Cartes, Rohault, Bacon, De Luc, Halley, Prevost, Derham, Eles, Muschenbroeck, Dalton, and others. We have

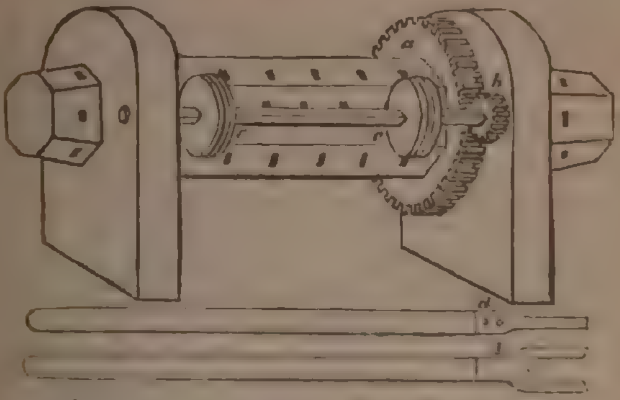
not room to introduce even a short abstract of their several theories, but must refer the curious reader to their writings, and the various parts of the *Philosophical Transactions.*

WIND-INSTRUMENTS. An accurate acquaintance with the principles of acoustics is essential to the scientific construction of every species of musical instrument, but especially those which owe their operation to the action of the wind. Wind-instruments generally produce their effects by the vibrations of a column of air confined at one end, and either open or shut at the other. These vibrations are determined mainly by the length of the sounding column; yet inferior and subordinate ones are found to coexist with the fundamental one. The whole column spontaneously divides itself into portions equal to the half, the third, or the fourth of its longitudinal extent. In mixed wind-instruments, the vibrations or alterations of solid bodies are made to cooperate with the vibrations of a given portion of air. Thus, in the trumpet, and in horns of various kinds, the force of inflation, and perhaps the degree of tension of the lips, determines the number of parts into which the tube is divided, and the harmony which is produced. In the serpent the lips cooperate with a tube, of which the effective length may be varied by opening or shutting holes; and the instrument which has been called an organised trumpet, appears to act in a similar manner. The trombone has a tube which slides in and out at pleasure, and changes the actual length of the whole instrument. The hautboy and the clarionet have mouth-pieces of different forms, made of reeds or canes; and the reed-pipes of an organ, of various constructions, are furnished with an elastic plate of metal, which vibrates in unison with the column of air which they contain.

The longitudinal vibrations of a column of air, contained within a tube open at both ends, are powerfully excited, and very loud and clear tones produced by the inflammation of a streamlet of hydrogen gas. This curious experiment was first made in Germany, and it is very easily performed. A phial, being partly filled with dilute sulphuric acid, a few bits of zinc are dropped into the liquid. As the decomposition of the water embodied with the acid now proceeds, the hydrogen gas, thus generated, flows regularly from the aperture. The gas being first ignited, and a glass tube placed over the exit-pipe, the burning speck at its point instantly shoots into an elongated flame, and creates a sharp and distinct musical sound. This effect is not owing to any vibrations of the tube itself; for it is in no way altered by tying a handkerchief tightly about the glass, or even by substituting a cylinder of paper. The tremor excited in the column of air is, therefore, the sole cause of the incessant tone, which only varies by a change in the place of the flame, or a partial obstruction applied at the end of the tube. The exciting force must necessarily act by starts, and not uniformly. The column of air contained within the tube is in reality agitated by a series of incessant strokes, or sudden expansion; and it is probable, that an instrument possessing great power in a small compass, might be thus constructed.

WINDLASS. A machine used on board ships, chiefly for raising the anchor. It may be regarded as a modification of the mechanical power termed the wheel and axle, employed to raise buckets from wells, and for infinite variety of other uses. In nautical affairs, it consists of a large cylindrical piece of timber, moving round its axis in a vertical position, and is supported at its two ends by two pieces of wood called knight-heads, which are placed on the opposite sides of the deck, near the foremast: it is turned about by levers called handspikes, which are for this purpose thrust into holes bored through the body of the machine. The lower part of the windlass is usually about a foot above the deck: it is furnished, like the capstan, with strong iron pauls, to prevent it from turning backwards by the pull of the cable and anchor, or from being strained by the violent jerking of the ship in a tempestuous sea. The pauls fall into notches cut in the surface of the windlass, and lined with plates of iron. The windlass is heaved round by the men who work it throwing their weight upon the ends of the handspikes, which, moving through a much greater space than the length

of the cable taken up, constitute, in effect, an increase of power equal to much greater space: and by this simple mechanical arrangement anchors of much greater weight than that of the men employed, are raised direct from the sea. It however requires considerable dexterity to manage the handspike to the most advantage: the sailors who perform it rise simultaneously upon the windlass, insert their levers, throw their weights to the extremities, by a sort of jerk, all at the same instant, and weigh up the anchor six or eight inches at each pull,—the motions of the men being regulated to time by the howling of one of the crew. To save the time employed by the men in working a windlass in raising the handspikes from one slot to another, and also to give additional power to the machine, a patent was recently taken out by Mr. George Straker, a ship-builder, of South Shields,—a perspective sketch of whose windlass is subjoined. The increase of power he obtains by fixing on the barrel of the windlass, at one end,



a spur wheel *a*, which is acted upon by a pinion *b*, whose axis turns in bearings which support the windlass itself. Upon each end of the pinion axis are fixed two circular appendages *c c*, which are formed like two crown ratchet wheels, with only four teeth in each, placed face to face, and with the teeth directly opposite to each other, and only about an inch apart, so as to leave cavities between them of a suitable form to receive handspikes of the shape represented in the above cut,—the upper figure showing the operating end edgeways, and the lower figure the same broadways; wherein is shown a fork or slot for the reception of the axis, when it is being turned round. This forked end is of course made of iron, and sufficiently thin to pass up between the projecting teeth of the pieces *c c*, when withdrawn a few inches; and by this means it can be raised with facility; and when it is pushed in, its shoulders *d d* rest on the projecting teeth, which enables the men to turn the pinion, and through that medium the windlass acts with great power. It will be perceived that by this arrangement, instead of having, as usual, to withdraw the handspikes, and insert them in a fresh hole every time they are brought down to the deck, they have only to be withdrawn until their shoulders can pass outside of the projecting teeth, moved past a second pair of teeth, and then returned again, till the shoulders rest firmly upon them. This is evidently a very convenient and excellent method of working a windlass, and might be applied, as stated by the patentee in his specification, to windlasses, without the intervention of the spur-wheel and pinion.

WINDMILL. A mill of any kind actuated by the impulse of the wind. They are of two kinds—*vertical* and *horizontal*.

Vertical windmills (to which a decided preference has been hitherto given)

usually consist of a strong shaft or axis inclining a little upwards from the horizon, with four long yards or arms fixed to the highest end, perpendicular to the shaft, and crossing each other at right angles. Into these arms are mortised several small cross bars, and to them are fastened two, three, or four long bars, running in a direction parallel with the length of the arms; so that the bars intersect each other, and form a kind of lattice-work, on which the cloth is spread to receive the action of the wind. These are called the sails, and are in the shape of a trepezium, usually about nine yards long and two wide. The direction of the wind being always very uncertain and variable, it becomes necessary to provide some contrivance for bringing the sails into a proper position for receiving its impression. Two methods have been devised for this purpose, one of which is denominated the post-mill, the other, the smock-mill.

The post-mill is so called from the circumstance of the mill being built round a massive central post, made out of the whole trunk of a stout tree, which is sunk vertically in the ground, and supported in its position by oblique struts or braces, which extend from a platform on the ground to the middle of the post, leaving 10 or 12 feet of the upper part free from the braces. The part thus left free from obstruction is rounded and made to pass through a circular collar, formed in the flooring of the lower chamber, and to enter into a socket fixed into the flooring of the upper chamber, and to one of the strongest cross-beams, which must sustain the whole weight of the mill-house; so that by means of a pivot, or gudgeon, fastened on that part of the post which enters into the socket, the whole machine can turn about horizontally to face the wind. A strong framing, united by joints at the back of the mill-house, descends in a sloping direction to the ground, and is there fastened to short posts, when placed in the position required for the sails to be acted upon by the wind. To this frame a ladder is attached, which leads into or out of the mill-house. To the bottom of this frame a rope is fastened and conducted to tackle in the mill-house, by which the frame can be lifted from the ground, while its position is being changed, in the manner of a capstan post, to suit the wind.

The smock-mill does not depend upon a central post for its main support, but it is generally a strong independent building, the upper portion of which is usually a tower of the form of a truncated cone, constructed of wood, and mounted upon a vertical wall of masonry, containing two or three floors, where the work of the mill is performed,—the tower above containing a vertical shaft, by which the motion and force is communicated from the sails to the mill-stones. The head or cap in the upper part of the mill is provided with a cap, which is contrived so that it may turn itself about as the wind changes; for this purpose there is a nearly horizontal framed projection at the back part of the head, which carries some small sails acting as a vane, there being, concentric with the axis, a large grooved ring, around which a circular hoop, provided with anti-friction rollers, traverses.

The velocity of motion of the sails or vanes is very considerable. Mr. Ferguson calculated the motion of the tips of the sails, even when operated upon by a very moderate wind, to be thirty miles per hour.

Horizontal windmills, as their name implies, are such as are worked by their sails revolving in a horizontal plane. All disinterested authors who have written on this subject condemn them, as being very inferior in effect to those of the vertical kind. Smeaton considered their effect to be only one-eighth, but Dr. Brewster shows that they have from one-third to one-fourth of the effect of the vertical. It is probable, however, that means may be discovered of improving them considerably.

To ascertain the best form and position of windmill-sails, Mr. Smeaton instituted a series of experiments, of which the results are given in the subjoined table :—

TABLE,

Exhibiting the Results of Nineteen Sets of Experiments on Windmill Sails, of various Structures, Positions, and Extents of Surface.

The Description of Sails made use of.	Number.	Angle at the Extremities.	Greatest Angle.	Turns of the Sails unloaded.	Turns of the Sails at the Maximum.	Load at the Maximum	Greatest Load.	Product.	Extent of Surface.	Ratio of greatest Velocity to the Velocity at a Maximum.	Ratio of greatest Load to the Load at a Maximum.	Ratio of Surface to the Product.
		Degrees	Degrees			lb.	lb.		Sq. In.			
Plane Sails, at an angle of 55°	1	35	35	66	42	7.56	12.50	318	404	10.7	10:6	10:7.9
Plane Sails, weathered according to the common practice	2	12	12	—	70	6.3	7.56	441	404	—	10:8.3	10:10.1
	3	15	15	105	69	6.72	8.12	464	404	10:6.6	19:8.3	10:10.15
	4	18	18	96	66	7.0	9.81	462	404	10:7	10:7.1	10:10.15
Weathered according to M'Laurin's Theory	5	9	26¼	—	66	7.0	—	462	404	—	—	10:11.4
	6	12	29½	—	70½	7.35	—	518	404	—	—	10.12.8
	7	15	32¼	—	63½	8.3	—	527	404	—	—	10:13.
Sails weathered in the Dutch manner, tried in various positions	8	0	15	120	93	4.75	5.31	442	404	10:7.7	10:8.9	10:11.
	9	3	18	120	79	7.0	8.12	553	404	10:6.6	10:8.6	10:13.7
	10	5	20	—	78	7.6	8.12	585	404	—	10.9.2	10.14.5
	11	7½	29½	113	77	8.3	9.81	639	404	10.6.8	10:8.5	10:15.8
	12	10	25	108	73	8.69	10.37	634	404	10:6.8	10:8.4	10:15.7
	13	12	27	100	66	8.41	10.91	580	404	10:6.6	10.7.7	10.14.4
Sails weathered in the Dutch manner, but enlarged towards the Extremities	14	7½	22½	123	75	10.65	12.59	790	505	10.6.1	10.8.5	10:15.8
	15	10	25	117	74	11.08	13.69	820	505	10.6.3	10:8.1	10:16.2
	16	12	27	114	66	12.09	14.23	799	505	10:5.8	10.8.4	10.15.8
	17	15	30	96	63	12.09	14.78	762	505	10:6.6	10.8.2	10:15.1
Eight Sails, being Sectors of Ellipses, in their best positions	18	12	22	105	64½	16.42	27.87	1059	854	10.6.1	10:5.9	10:12.4
	19	12	22	99	64½	18.06	—	1165	1146	10.5.9	—	10.10.1

WINDOW. An aperture in the wall of a building, for the admission of light and air. Modern windows are almost uniformly furnished with glazed frames, that open and close, besides shutters and blinds, by which the admission of the light and air may be easily regulated at pleasure.—See the Article GLAZING. In this place we propose to notice several improvements which have of late years been made in the mechanical construction of windows.

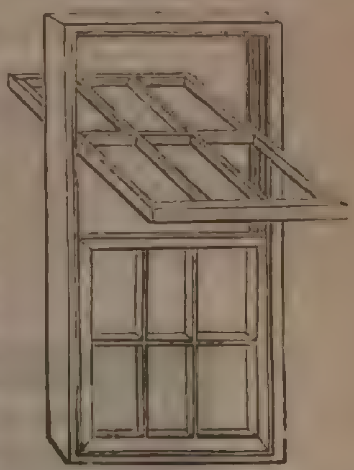
It has frequently been a subject of complaint, that our public edifices are either insufficiently provided with the means of ventilation, or the arrangements for that purpose are very inconvenient. The oldest mode with which we are acquainted is that of casements hung upon hinges, and fastened by a latch. A later and more improved method was to hang the casements so as to swing upon centre pivots; the opening and shutting of these casements by pulleys and lines is always accompanied with noise, and they afford no defence from a shower of rain, nor to the prejudicial effects of the cold air descending on the heads of the persons assembled near to the windows. Another mode, lately introduced, is to cut out of the windows a space to receive the half of a glazed hopper, which is attached to the window, projecting inwards, having a flap on the top, lying horizontally, and opening upwards. These hoppers are extremely

Fig. 1. *Fig.* 2.

unsightly in themselves, but are rendered still more so by the dust which lodges on them; which dust is blown into the building when the flap is opened for the admission of air. To remedy these inconveniences, Messrs. W. and D. Baily some years ago invented the arrangement delineated in the preceding page, by which a ready mode of action on the upper part of the window is obtained by very simple machinery, while the symmetry of the window is preserved. *Fig.* 1 gives a front inside view of a window, with the apparatus attached, and *fig.* 2 is a side view of the same; *a* shows the flap of the window open; *b b* a bar to which the base of the flap is fixed, and on which it turns; *c* a lever having one end fastened to the extremity of the bar *b*, and furnished at the other end with an eye, which receives the pin or stud *d*; this stud is fixed on the vertical rod *e*, which terminates below in a rack *f*, and is secured to an

upright position by the loops or guides *g g*, through which it passes; *h* is a lanthorn pinion of two teeth, which when turned round by means of the winch *i*, takes into the notches of the rack, and consequently draws down the rod *e*, or raises it, according to the direction in which the winch is turned. In the first case, the stud *d* draws the lever down, and consequently *opens* the window; in the latter the stud is raised, and with it the lever, which *shuts* the window. It may be proper to observe, that in case of the upper part of the window being square, and not having any mullions, it will be found necessary (to prevent the entrance of the air at the side of the casement, when it opens) to have a frame with two angular sides attached to the windows, and these sides must have a small return rebate for the casement to fall against when it is fully opened, which will prevent any inconvenience arising from the form of the window.

Servants and others employed in the cleaning and repairing of such windows in general provide so indifferently for their security, while employed on the outside, that numerous accidents have occurred,—some, of the most deplorable nature. The construction of the sash windows that we have now to notice, will not only effectually prevent these accidents, but will remain a permanent convenience to the house in which they may be adopted. In appearance these sashes resemble those of the common kind, and the upper and lower sash may be moved up and down in a similar manner. The outside of the sash may also be turned into the room, so that it may be easily painted, glazed, or cleaned, by a person standing within the room, without the necessity of removing the slips or beadings; by doing which the glass is frequently broken, and the beads lost, left loose, or dismatched, and a considerable expense incurred. The frame of the window is fitted with grooves, weights, and pulleys, in the usual manner; the fillets on the sash are not made in the same piece with the sash frame, but fastened thereto by pivots, about the middle of the sash; upon these pivots the sash is turned round at pleasure, so as to get at the outside without disturbing the fillets or grooves. When the sash is placed vertically (as the lower one in the figure) a spring catch on each side of it shoots into, and takes hold of the sliding fillets; so that in this case the sash slides up or down in the usual manner, but can be immediately released, and turned inside-out by pushing back the springs, and at the same time pulling the sash inwards. This invention originated with Mr. Marshall, who communicated it to the Society of Arts; but the invention, with some unimportant modifications, was subsequently patented by Mr. Tuely, probably from ignorance of Mr. Marshall's prior claims. We notice this fact, as windows of this kind are sometimes called Marshall's, and at others Tuely's patent revolving windows. On account of the additional expense (from six to twelve shillings) of these windows above the ordinary kind, the builders do not encourage them; but this additional expense is scarcely worthy of notice by a private individual in building, when the important advantages it confers are taken into account.



To keep the sashes of ordinary windows at equal distances from the sides, so that they may not be impeded in drawing up and down, (as is often the case, on account of the sash swinging as it is suspended by the top,) Mr. Woolwich has proposed the simple appendage represented in the annexed cut. *Fig.* 1 is a plate of iron two inches long by one inch wide; to the lower part of which is fixed a spring *b*, that carries a roller at its upper end, and at *c c* are two holes

below the window. The patentees likewise claim the public patronage for another property possessed by their metallic shutters,—that of a ready conversion into sun-blinds; but there will doubtless be many exceptions taken to the employment of so quick a conductor of heat, and of so ponderous a material as iron, for such a purpose. But whatever may be the substance used, the obviating of the necessity of sun-blinds as a separate appendage is worthy of consideration.

In the annexed engraving is represented a perspective view of the corner-house of a street, in which the metallic shutters and sun-blinds are exhibited as applied thereto. At *a* is a shop-window, and at *b* a shop-door, over which is

projected two of the metallic shutters as a sun-blind, having also end blinds of silk cloth or other desirable substance, in the form of sectors of circles. In this case the third shutter, which forms the set, is drawn up and deposited behind the entablature. On the first floor above the shop, *c c* exhibits the application of the same thing on a small scale to private windows. At *d* is shown a window unclosed; that is, the shutters are supposed to be withdrawn entirely, and deposited immediately above or below it, as the patentees adapt them to both situations. At *e* is a window entirely closed by the shutters, presenting a barrier against burglars, said to be bullet-proof; and at *o* is shown one of the shop windows, similarly closed. The shutters are made in the following manner. Having determined the number of plates or pannels a shutter is to contain, (usually three or four,) the iron or steel plates are well hammered in the manner of saw plates, so as to condense the metal and flatten the surfaces. The plates are then enclosed in grooves made in a rectangular frame of bar-iron, and strongly rivetted thereto. Thus framed, they are connected together at

pleasure, by the lower horizontal bar of one, and the upper one of the next being cut into acute angles, that hook into one another; and they are thus drawn up or let down in succession, by sliding with their vertical sides in deep grooves cut in bars of wrought iron, which form the styles to the window. The upper portion of these grooved metallic styles is made to separate from the lower, by turning upon a pivot or hinge joint, at the top of the window, by which means the shutters, while contained in the grooves, may be projected out to an angle of about 60 degrees from the perpendicular, and form the sun-blinds. The patentees have designed several movements for raising or lowering the shutters; but we adopt that which is specified under the patent, with reference to the annexed sectional figure. From *a* and *b* to *c* and *d*, is one of

the side styles to the window; from *a* to *f* is a continuation of the style and frame behind the entablature, where all the three shutters *g*, *h* and *i*, are drawn up and deposited, when the shutters are not in use. The groove for the upper shutter *g* does not permit it to descend lower than *b*, nor does the groove for the middle shutter *h* permit that to descend further than *c*, but the groove for the lower shutter *i* is extended from the top *f* to the bottom *d*. The sun-blind is projected only when they are all down, by which means the two upper shutters are unlocked from the lower, and the latter is afterwards drawn up to the top, as shown in the figure. To the movable part of the style is fixed a curved rack *k*, the teeth of which geer into those of a pinion *l*; the axis of this pinion carries a winch *m*, by turning which, the sun-blind is thrown out, or drawn in. To steady the motion of the blind, the movement described is made to communicate with a similar rack and pinion on the opposite side of the window; for this purpose there is placed on the axis of the pinion *l* behind it, a small chain

pulley, round which an endless pitched chain *n* passes, and also over a similar pulley *o*; the axis of the last mentioned is a long shaft, extending horizontally across the window (above the glass) to the opposite side, where a corresponding apparatus projects, and supports that side of the sash blind. In order to fix the blind at any required angle that it may be desired to project it, there is on the axis of *i*, a ratchet-wheel, with a pall above *p*, which falls into the teeth on its periphery, and prevents its return without being lifted up.

The side or end blinds, one of which is represented at *g*, are made of cloth, or other flexible substance; one side is attached to the projecting part of the style, and the other, passing through a long and very narrow slit, is attached to a conical roller *r*; when the shutters composing the blind are drawn in, the conical roller is turned by means of a descending weight *s*, which then winds upon it, in even layers, the sectorial blind. To the middle of the lower edge, and at the back of the bottom shutter *i*, a suitable line or chain is attached. This line is carried up vertically, then passes over a pulley at the top of the frame, and from thence over side pulleys down to a barrel on one side, on which the cord is wound. The lower ledge of the shutter *i* has likewise a projecting ledge; on the drawing up of the lower shutter, therefore, by the cord and winch described, the bottom edges of the middle and upper shutters come in contact with, and rest upon the ledge, and are thereby carried up altogether into the casing behind the entablature; to keep the shutters in the situation they are thus put, a pall drops into the teeth of another ratchet-wheel placed on the axis of the winding barrel.

Subsequent improvements have been effected upon the foregoing, which chiefly consist in substituting, for the movement we have described, long revolving screws extending from top to bottom on each side of the window. A simultaneous motion is effected in the screws, by means of a bar extending across the bottom of the window, and connecting, by bevil wheels, both screws with a winch handle by which they are turned. Upon the screws are fitted nuts, to which are attached the shutters; and, therefore, by the operation of turning the handle, the shutters are steadily raised or lowered into or out of their case.

WINE. A term applied by chemists to all liquids that have become vinous by fermentation; but it is popularly considered as confined to saccharine vegetable substances that have been converted into a vinous liquid. It seems to be a necessary condition, that sugar must be present in a vegetable, to enable it to ferment and become vinous; but this, according to late discoveries, will not exclude starch, gum, and other similar products, which are capable of being converted into saccharine matter. Lavoisier stated that pure sugar alone would not ferment, but that some extractive matter, or yeast, must be added to enable it to undergo the vinous fermentation; and he considered that the effects of this fermentation consisted in separating the sugar, which is an oxide, into parts; in oxygenating the one, at the expense of the other, to form carbonic acid; in disoxygenating the other in favour of the first, to form a combustible substance termed alcohol; so that, were it possible to combine these two substances, the alcohol and the carbonic acid might reproduce sugar. It is necessary to remark, that the hydrogen and carbonic do not exist in the state of oil in alcohol, being combined with a portion of oxygen, which renders them miscible with water. These three principles, therefore, the oxygen, the hydrogen, and the carbonic, are here in a kind of equilibrum; and, in fact, by causing them to pass through a red-hot tube of glass or porcelain, we may recombine them, two and two together, and the product will be water, hydrogen, carbonic acid, and carbon.

In all wines may be distinguished an acid, alcohol, tartar, an extractive matter, aroma or odour, and a colourless principle,—the whole being diluted or dissolved in a smaller or larger proportion of water. An acid exists in all wines, but all are not acid in the same degree. Of some wines a natural acidity is the principal characteristic; those produced from grapes not perfectly ripe, or that grow in moist climates, are of this kind; whilst such as are the product of the fermentation of grapes that have attained complete maturity and sweetness, contain but a very small quantity of acid. The proportion of acid appears, therefore, to be in the inverse ratio of the saccharine principle, and consequently of the alcohol, which is produced by the decomposition of the sugar. Alcohol forms the true

characteristic of wine It is the product of the decomposition of sugar; and its quantity is always proportionate to that of the sugar that has been decomposed. Alcohol abounds more in some wines than it does in others; those of hot climates contain a large quantity of it; whilst those of cold climates contain scarcely any. Ripe and sweet grapes produce it in abundance; but the wines made of grapes that are unripe, watery, and sour, yield very little.

The following is Mr. Brande's valuable table of the quantity of alcohol in different kinds of wine and spirituous liquors:—

	Proportion of Alcohol per cent by measure
1. Lissa, average of two samples	25.41
2. Raisin wine, average of three samples	25.12
3. Marsala, average of two samples	25.9
4. Madeira, average of four samples	22.27
5. Currant wine	20.55
6. Sherry, average of four samples	19.17
7. Teneriffe	19.79
8. Colares	19.75
9. Lachryma Christi	19.70
10. Constantia, white	19.75
11. Ditto . . red	18.92
12. Lisbon	18.94
13. Malaga, (1666)	18.94
14. Bucellas	18.49
15. Red Madeira, average of two samples	20.35
16. Cape Muschat	18.25
17. Cape Madeira, average of three samples	20.51
18. Grape wine	18.11
19. Calcavella, average of two samples	18.65
20. Vidonia	19.25
21. Alba Flora	17.26
22. Malaga	17.26
23. White Hermitage	17.43
24. Roussillon, average of two samples	18.13
25. Claret, average of four samples	15.10
26. Malmsey Madeira	16.40
27. Lunel	15.52
28. Sheraaz	15.52
29. Syracuse	15.28
30. Sauterne	14.22
31. Burgundy, average of four samples	14.57
32. Hock, average of three samples	12.08
33. Nice	14.63
34. Barsac	13.86
35. Tent	13.30
36. Champagne, average of four samples	12.61
37. Red Hermitage	12.32
38. Vin de Grave, average of two samples	13.37
39. Frontignac	12.79
40. Cote Rotie	12.32
41. Gooseberry wine	11.84
42. Orange wine, average of six samples, made by a London manufacturer	11.26
43. Tokay	9.88
44. Elder wine	9.87
45. Cider, highest average	9.87
Ditto lowest ditto	5.21
46. Perry, average of four samples	7.26
47. Mead	7.32

		Proportion of Alcohol per cent. by measure.
48.	Ale, (Burton)	9.88
	Ditto (Edinburgh)	6.20
	Ditto (Dorchester)	5.56
49.	Brown Stout	6.80
50.	London Porter, average	4.20
51.	Ditto Small Beer, ditto	1.28
52.	Brandy	53.39
53.	Rum	53.68
54.	Gin	51.60
55.	Scotch Whiskey	54.32
56.	Irish ditto	53.90

Tartar exists in verjuice, as also in must; it contributes to facilitate the formation of alcohol. When left at rest in casks, it deposits itself upon the sides, forming a crust more or less thick, with crystals of irregular forms. Some time before the vintage, when the casks are to be got ready for receiving the new wine, they are staved, and the tartar detached from them, in order to be employed in the different uses of commerce. This salt has little solubility in cold water, but considerably more in boiling water. It scarcely dissolves at all in the mouth, and it resists the pressure of the teeth. The extractive principle abounds in must, when it appears to be dissolved by the aid of the sugar, but when the saccharine principle is decomposed by means of fermentation, the quantity of extractive matter sensibly diminishes, a part of it deposits itself in a fibrous form, and this deposit, which principally constitutes the lees, is the more considerable in proportion as the fermentation is more gentle, and the alcohol more abundant. This deposit is always mixed with a considerable quantity of tartar. There always exists in wine, a proportion of extractive matter in a state of solution, which may be separated from it by means of evaporation. It abounds more in new wines than in old ones; and the older the wine grows, the more completely is it freed from the extractive principle. All natural wines have an odour more or less agreeable to the smell. Some of them owe their reputation in a great measure to the perfume which they exhale. This is the case with Burgundy. This perfume is lost by too violent a fermentation, and becomes stronger by age. It seldom exists in very spirituous wines, either because it is concealed by the strong smell of the alcohol, or because it has been destroyed or dissipated by the violent fermentation that was requisite to develop the spirit. The colouring principle of wine belongs to the skin of the grape; for when the must is suffered to ferment without it, the wine is white. The colouring principle does not dissolve till the alcohol is developed, it is only then that the wine acquires its colour, which is deeper in proportion to the violence of the fermentation. If we expose bottles filled with wine to the rays of the sun, a few days are sufficient to precipitate the colouring principle in large pellicles; the wine losing neither its perfume nor its strength.

A very great number of vegetable substances may be made to afford wine, as grapes, currants, mulberries, elders, cherries, apples, pulse, beans, peas, turnips, radishes, and even grass itself. Hence, under the class of wines, or vinous liquors, come not only wines, absolutely so called, but also ale, cyder, &c. The term wine is however in a more particular manner appropriated to the liquor drawn from the fruit of the vine. The process of making wine is as follows:—When the grapes are ripe, and the saccharine principle is developed, they are then pressed, and the juice which flows out is received in vessels of a proper capacity, in which the fermentation appears, and proceeds in the following manner. At the end of several days, and frequently after a few hours, and according to the heat of the atmosphere, the nature of the grapes, the quantity of the liquid, and temperature of the place in which the operation is performed, a movement is produced in the liquor, which continually increases; the volume of the fluid increases; it becomes turbid and oily; carbonic acid is disengaged, which fills all the unoccupied part of the vessel, and the temperature rises to

75° Fahrenheit. The skins, stones, and other grosser matters of the grapes, are buoyed up by the particles of disengaged air that adhere to their surface, are variously agitated, and are raised in form of a scum, or soft and spongy crust, that covers the whole liquor. During the fermentation, this crust is frequently raised, and broken by the air disengaged from the liquor, which forces its way through it; afterwards the crust subsides, and becomes entire as before. These effects continue while the fermentation is brisk, and at last gradually cease: then the crust being no longer supported, falls in pieces to the bottom of the liquor. At this time, if we would have a strong and generous wine, all sensible fermentation must be stopped: this is done by putting the wine into close vessels, and carrying these into a cellar or other cool place. After this first operation, an interval of repose takes place, as is indicated by the cessation of the sensible effects of the spirituous fermentation; and thus enables us to preserve a liquor, no less agreeable in its taste, than useful for its reviving and nutritious qualities when drunk moderately. In this new wine a part of the liquor probably remains, that has not fermented, and which afterwards ferments, but so very slowly, that none of the sensible effects produced in the first fermentation are here perceived. The fermentation, therefore, still continues in the wine, during a longer or shorter time, although in an imperceptible manner; and this is the second period of the spirituous fermentation,—which may be called the imperceptible fermentation. We may easily perceive that the effect of this imperceptible fermentation is the gradual increase of the quantity of alcohol. It has also another effect no less advantageous; namely, the separation of the acid salt called tartar from the wine. This matter is therefore a second sediment that is formed in the wine, and adheres to the sides of the containing vessels. As the taste of tartar is harsh and disagreeable, it is evident that the wine, which, by means of the insensible fermentation, has acquired more alcohol, and has disengaged itself of the greater part of its tartar, ought to be much better and more agreeable; and for this reason chiefly, old wine is universally preferable to new wine. But insensible fermentation can only ripen and meliorate the wine, if the sensible fermentation have regularly proceeded, and been stopped in due time. We know certainly, that if a sufficient time have not been allowed for the first period of the fermentation, the unfermented matter that remains, being in too large a quantity, will then ferment in the bottles or close vessels in which the wine is put, and will occasion effects so much more sensible as the first fermentation shall have been sooner interrupted; hence these wines are always turbid, emit bubbles, and sometimes break the bottles, from the large quantity of air disengaged during the fermentation.

We have an instance of these effects in the wine of Champagne, and in others of the same kind. The sensible fermentation of these wines is interrupted, or rather suppressed, that they may have this sparkling quality. It is well known that these wines make the corks fly out of the bottles; that they sparkle and froth when they are poured into glasses; and lastly, that they have a taste much more lively and piquant than wines that do not sparkle; but this sparkling quality, and all the effects depending on it, are only caused by a considerable quantity of carbonic acid gas, which is disengaged during the confined fermentation that the wine has undergone in close vessels. This air not having an opportunity of escaping, and of being dissipated as fast as it is disengaged, and being interposed betwixt all the parts of the wine, combines in some measure with them, and adheres in the same manner as it does to certain mineral waters, in which it produces nearly the same effects; when this air is entirely disengaged from these wines they no longer sparkle, they lose their piquancy of taste, become mild, and even almost insipid.

Such are the qualities, Dr. Ure observes, that wine acquires in time, when its first fermentation has not continued sufficiently long. These qualities are given purposely to certain kinds of wine, to indulge taste or caprice; but such wines are supposed to be unfit for daily use. Wines for daily use ought to have undergone so completely the sensible fermentation, that the succeeding fermentation shall be insensible, or at least exceedingly little perceived. Wine, in which the first fermentation has been too far advanced, is liable to worse

inconveniences than that in which the first fermentation has been too quickly suppressed; for every fermentable liquor is, from its nature, in a continual intestine motion, more or less strong according to circumstances, from the first instant of the spirituous fermentation, till it is completely purified; hence, from the time of the completion of the spirituous fermentation, or even before, the wine begins to undergo the acid, or acetous fermentation. This acid fermentation is very slow and insensible, when the wine is included in very close vessels, and in a cool place; but it gradually advances, so that in a certain time the wine, instead of being improved, becomes at last sour. This evil cannot be remedied; because the fermentation may advance, but cannot be reverted.—*Fourcroy, Ure, Brande. Oxford Cyclopedia.*

WIRE. Metallic threads, or fine rods, produced by forcibly drawing the ductile metals through a hole of less area than their previous transverse sections. The sizes of which wire are made are from three-eighths of an inch in diameter to that of the four-thousandth part of an inch. For the purposes of embroidery and similar work, gold and silver are commonly drawn to such fineness as to be flexible, and as conveniently wrought with a needle, as the filaments of silk, flax, &c. with which they are usually mixed. See the articles Gold and Silver.

The earliest attempt to draw ductile metal into threads, by forcing them through holes in a steel plate, does not appear to be determined. At first, wire was formed entirely by the hammer; and this process of art soon became a distinct trade. Beckman observes, "As long as the work was performed by the hammer, the artists at Nuremberg were called *wire-smiths*, but after the invention of *drawing* iron, they were called *wire-drawers*, or *wire-millers*. Both these appellations occur in the history of Augsburg, so early as the year 1351, and in that of Nuremberg, in 1360; so that, according to the best information I have been enabled to obtain, I must class the invention of the drawing-iron or proper wire-drawing, among those of the fourteenth century." About two hundred years, however, elapsed before the art was introduced into this country; nevertheless, the skill of our native artists soon enabled them to surpass the foreign manufacture, if any reliance can be placed in the statement contained in a proclamation of King Charles I. in 1630, wherein it is set forth, "That iron-wire is a manufacture long practised in the realm, whereby many thousands of our subjects have long been employed; and that English wire, of the toughest and best Osmond iron, a native commodity of this kingdom, and is much better than what comes from foreign parts, especially for making wool-cards, without which no good cloth can be made."

For the manufacture of wire for piano-fortes and other musical instruments, Berlin has long been celebrated; and it still deserves a preference for these purposes, in the opinion of many of our artists.

For making iron wire, none but the very best and toughest iron should be used, that made entirely from charcoal and of the Cumberland ore having the preference. Formerly the bars were reduced to the required sizes for the wire-drawer by tilting it; but now we understand the manufacturers roll the bars down through small grooved rolls to very small sizes, and thus materially save the labour of drawing. The rolls for this purpose are the same as described in the article Iron (which see,) but are superiorly finished, and fitted up with great accuracy of adjustment, so as to roll very perfect cylinders of wire down to an eighth of an inch in diameter. The rollers are generally from seven to eight inches in diameter, and make upwards of 300 revolutions per minute; so that the rapidity with which this rolled or "black wire," (as it is sometimes called, to distinguish it from the bright, or drawn-wire,) is made, may be readily conceived. For the rims of pots, kettles, and other kinds of "hollow ware," as made by the tinmen or braziers, wherein the copper or tinned plate is wrapped round the wire, the black wire is equally useful with the bright; for these purposes, and all others where the wire is hidden, or is to be painted, the rolled black wire is preferred, on account of its greatly inferior cost. Whether wire be drawn by water, steam, or hand-power, the process is nearly the same, and the tools very similar. In order to get the end of the wire through the first reducing hole in the draw-plate, it is sharpened by hammering or filing; being then inserted through the plate, the latter is laid so as to take its bearing

against two stout pins fixed vertically in a solid, firm, bench, and the end of the wire is griped by a pair of pincers attached to a chain; the cross lever of these pincers are so formed, that the chain when pulled has a tendency to draw them together, and in proportion to the force applied to them, do they bite or gripe the wire; by means of a powerful lever the wire is now drawn through the hole in the plate, which is well lubricated with grease; and when a sufficient extent has been thus drawn through, the end of the wire is fastened to a cylinder to which the power is applied, and the wire coiled upon it as it comes through the plate. The new wire thus drawn is very stiff and hard, and requires annealing prior to the next drawing process. When annealed it is put into a vessel containing an acid liquor, and then scoured bright before it is passed through a second or smaller hole, in which the operation is repeated as many times as may be found necessary to reduce it to the size required,—annealing, treating with acid, and scouring, at every succeeding operation. It is said, that in order to heat this acid liquor, at an eminent manufactory, some ingots of brass which were at hand were heated red hot and quenched in it. It was afterwards found that the iron wire treated with this acid liquor, was covered with a thin film of copper, (derived from a slight solution of the heated ingot to the acid,) and that the wire was in consequence drawn through the plates with much greater facility than usual, the copper evidently acting as a lubrication to decrease the attrition between the wire and the draw-plate. In consequence of this accidental discovery, the practice has been since continued at the manufactory, of employing a weak solution of copper in the acid liquor used in iron and steel wire-drawing. The slight coat of copper is got rid of in the last annealing process.

To produce a perfect and durable wire-drawing plate, is a work of considerable art; and British skill has in this respect been long surpassed by the French, from whom all our best "draw-plates" are obtained. The process by which our ingenious neighbours attain their superiority, must therefore be of sufficient importance to our countrymen, to entitle it to a place in our work. In vol. xv. of *Les Arts et Métiers* is the following account of the process, by M. Du. Hamel.

"A band of iron is forged, of two inches broad, and one inch thick. This is prepared at the great forge. About a foot in length is cut off, and heated to redness in a fire of charcoal. It is then beaten on one side with a hammer, so as to work all the surface into furrows or grooves, in order that it may retain the substance called the potin, which is to be welded upon one side of the iron, to form the hard matter on which the holes are to be pierced. This potin is nothing but fragments of old cast-iron pots; but those pots which have been worn out by the continued action of the fire, are not good; the fragments of a new pot, which has not been in the fire, are better.

"The workman breaks these pieces of pots on his anvil, and mixes the pieces with charcoal of white wood. He put this in the forge, and heats it till it is melted into a sort of paste; and to purify it, he repeats the fusion ten or twelve times, and each time he takes it with the tongs to dip it in water." M. Du Hamel says, this is to render the matter more easy to break into pieces.

"By these repeated fusions with charcoal, the cast iron is changed, and its qualities approach those of steel, but far from becoming brittle, it will yield to the blows of the hammer, and to the punch, which is used to enlarge the holes. The bar of iron which is to make the draw-plate, is covered with a layer of pieces of the potin, or cast iron thus prepared. It is applied on the side which is furrowed, and should occupy about half an inch in thickness. The whole is then wrapped up in a coarse cloth, which has been dipped in clay and water, mixed up as thick as cream, and is put into the forge. The potin is more fusible than the forged iron, so that it will melt. The plate is withdrawn from the fire occasionally, and hammered very gently upon the potin, to weld, and in some measure amalgamate it with the iron, which cannot be done at once; but it must be repeatedly heated and worked, until the potin fixes to the iron. The workman then throws dry powdered clay upon it, in order, they say, to soften the potin.

"The union being complete, the plate is again heated, and forged by two workmen, who draw out the plate of one foot to a length of two feet, and give it the

form it is to have. It is well known, that cast iron cannot be worked at the forge without breaking under the hammer; but in the present instance, it is alloyed with the iron-bar, and is drawn out with it. It has also acquired new properties by the repeated fusions with charcoal.

"The holes are next pierced whilst the plate is hot. This is done with a well-pointed punch of German steel, applied on that side of the plate which is the iron-bar. It requires four heats in the fire to punch the holes, and every turn a finer punch is employed, so as to make a taper hole. The makers of draw-plates do not pierce the holes quite through, but leave it to the wire-drawers to do it themselves when the plate is cold, with sharp punches, and then they open the hole to the size they desire; and although this potin is of a very hard substance, the size of the hole may be reduced by gentle blows with a hard hammer, on the flat surface of the plate round the hole.

"A great many holes are made in the same plate; and it is important that they should diminish in size by very imperceptible gradations; so that the workman can always choose a hole suitable for the wire he is to draw, without being obliged to reduce it too much at once."

The next considerable wire manufactory in France, and probably in the world, is that of the Messrs. Mouchel, situated at L'Aigle, in the department of L'Orne. It furnishes annually in cards, for wool-combing only, 100 000 quintals of iron-wire = 10 millions of pounds! The whole of this is not required for home consumption, but is exported to Spain, Portugal, Italy, and other countries. As the excellence of their products is in a great measure attributable to the perfection of their draw-plates, we shall here add the process of preparing them, as described by the Messrs. Mouchel, which differs from that previously explained.

"Several pieces of iron are disposed in the furnace, in the form of a box without a lid, their weight being according to the use for which they are intended to be made. The workman fills each of these boxes with cast steel, and having covered it over with a luting of clay, it is exposed to a fierce fire until the steel be melted. His art consists in seizing the proper moment to withdraw the plate from the fire; he raises the luting, and blows on it through a tube, in order to drive off all heterogeneous parts, and then amalgamates it with the iron by light blows; after it is cool, he replaces it at the fire, where the fusion again takes place, but to a less degree than before; he afterwards works the steel with light blows of the hammer, to purify and solder it with the iron. This operation is repeated from seven to ten times, according to its quality, which renders it more or less difficult to manage. During this process, a crust forms on the steel, which is detached from it the fifth time of its exposure to the fire, because this crust is composed of an oxidated steel, of an inferior quality. It sometimes happens that two, and even three, of these crusts are formed of about two millimetres, or one-sixteenth of an inch, in thickness, which must also be removed.

"After all these different fusions, the plate is beaten by a hammer wetted with water, and the proper length, breadth, and thickness, are given to it. When thus prepared, the plates are heated again, in order to be pierced with holes by punches of a conical form; the operation is repeated five or six times, and the punches used each time, are progressively smaller. It is of importance that the plate never be heated beyond a cherry-red, because if it receives a higher degree of heat, the steel undergoes an unfavourable change. The plates, when finished, present a very hard material, which nevertheless will yield to the strokes of the punches and hammer, which they require when the holes become too much enlarged by the frequent passing of the wire through them.

"When the plates have been repaired several times, they acquire a degree of hardness which renders it necessary to anneal them, especially when they pass from one size to another; sometimes they do not acquire the proper quality until they have been annealed several times. Notwithstanding all the precautions which are taken in preparing the plates, the steel still varies a little in hardness, and according to this variation they should be employed for drawing either steel or iron-wire; and if the workman who proves them finds that they

are too soft for either the steel or iron, they are put aside, to be used by the brass-wire drawers.

"A plate that is best adapted for drawing of steel wire is often unfit for the iron; for the long pieces of this latter metal will become smaller at the extremity than at the beginning, because the wire, as it is drawn through the plate, is insensibly heated, and the adhering parts are swelled, consequently pressed and reduced in size towards the latter end. The plates that are fit for brass are often too soft for iron, and the effect resulting is the reverse of that produced by a plate that is too hard.

"The smallest plates which Messrs. Mouchel use are at the least two centimetres, or eight-tenths of an inch, in thickness, so that the holes can be made sufficiently deep; for when they are of a less thickness they will seize the wire too suddenly, and injure it.

"This inconvenience is much felt in manufactories where they continue to use the plates for too long a time, as they become exceedingly thin after frequent repairs. One of Messrs. Mouchel's large plates reduces 1,400 kilogrammes (3,080 lbs. avoirdupois) from the largest size of wire to No. 6, which is of the thickness of a knitting-needle; 400 kilogrammes (880 lbs.) of this number are afterwards reduced in one single small plate, to No. 24, which is carding-wire; and to finish them, they are passed through twelve times successively. Wires are frequently drawn so fine as to be wrought along with other threads of silk, wool, or hemp; and thus they become a considerable article in the manufactures."

"Dr. Wollaston, in 1813, communicated to the Royal Society, the result of his experiments in drawing wire. Having required some fine wire for telescopes, and remembering that Muschenbrock mentioned wire 500 feet of which weighed only a single grain, he determined to try the experiment, although no method of making such fine wire had ever yet been published. With this view, he took a rod of silver, drilled a hole through it only one-tenth its diameter, filled this hole with gold, and succeeded in drawing it into wire till it did not exceed the three or four-thousandth part of an inch, and could have thus drawn it to the greatest fineness perceptible by the senses. Drilling the silver he found very troublesome, and determined to try to draw platina wire, as that metal would bear the silver to be cast round it. In this he succeeded with greater ease, drew the platina to any fineness, and plunged the silver in heated nitric acid, which dissolved it, and left the gold or platina wire perfect."

In 1819 a patent was taken out by Mr. Brockedon, for mounting the wire-drawing plates with diamonds, sapphires, rubies, and other hard gems; in these conical holes were to be drilled, with their extremities rounded off, which were afterwards to be polished by the processes known to lapidaries. By these means it was expected the wire might be more equally and cylindrically drawn, owing to the impenetrable hardness of the gems, which would not sensibly wear from the same cause.

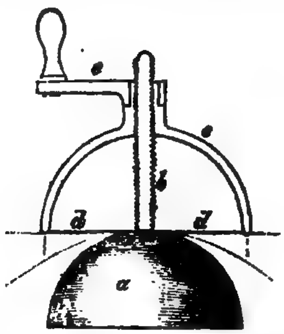
As the repeated annealings to which iron wire is subjected, to cause it to yield to the resistance of the draw-plate, would be destructive of the property from which steel derives its utility, steel wire, therefore, during the process of annealing, is surrounded with charcoal-dust from which carbon is reabsorbed in the furnace; thus the metal is rendered very soft and yielding, without losing its steel property.

Among the curious and important "results of machinery" might be mentioned the manufacture and application of steel wire to the making of the hair-springs of watches. "A pound of crude iron costs one half-penny; it is converted into steel; that steel is made into watch-springs; every one of which," it is said, "is sold for half a guinea, and weighs only the tenth of a grain, after deducting for waste, there are in the pound weight about 7,000 grains; it therefore affords steel for 70,000 watch-springs, the value of which, at half a guinea each, is 35,000 guineas!" Now as there are 504 half-pence in a guinea, the pound of crude iron has increased 17,640,000 times in value.

The looms employed for weaving wire-cloth are not essentially different to the looms employed for weaving other filaments, and several patents have been

taken out for modifications of the power-loom, to adapt it to weaving of wire; which are described in the *Repertory and Journal of Patent Inventions.*

The application of wire-gauze to the manufacture of baskets, dish-covers, and a great variety of useful articles, took place about ten years ago, under a patent granted to Mr. Gosset, of the Haymarket, London, who brought the invention from abroad. The annexed cut is explanatory of the process of conversion.



The operation is exceedingly simple, being performed entirely by forcing the wire-gauze between moulds of the required shape, by the power of a screw press, which causes the figure or pattern thus given to it, to be permanently retained after the article has been withdrawn from the mould. We extract the following from the specification before us:—

"It consists of a pattern or block *a*, of metal, wood, or other suitable material, which is formed on the exterior surface to the desired shape and size of the article intended to be produced. The block *a* has a screw *b*, projecting up from the top or crown thereof; *c* represents a pattern or mould made in like manner, of any suitable material; the interior surface of this mould is formed to the desired shape of the article intended to be produced, and has an aperture made in the crown thereof, so as to be capable of passing over the screw *b*, and thus permit the mould *c* to come down over the block *a*, as shown in the figure.

The manner of using the machine is as follows: the metallic wire-gauze or other material, (which is intended to be shaped,) has a hole made through it, and is passed over the screw *b*, so as to rest upon the crown of the block *a*, as seen at *d d*. In this situation, the upper mould *b* is placed upon the said metal or gauze-wire, with the screw passing through its aperture, as aforesaid; and the nut or handle *c* is put on its place, and is turned down upon the screw *b*, by which means it presses down the upper mould *c* upon the metallic wire-gauze, or other material, and thereby forces it into the cavity or space between the block *a* and mould *c*, so as to give it the desired shape of the article required. The apparatus is then inverted, and placed upon a bench, or other convenient support, with the screw *b* projecting downwards; and a ring or hoop of tinned wire, or other suitable material, is inserted within the lower edge of the article, and is soldered, or otherwise securely fixed, to the wire-gauze or other material, of which the article is formed. The nut *e* may then be screwed to the back of the screw *b*, and the mould and block may be separated, so as to take out the article, which will be found to retain the pattern or shape given to it by the said mould or machinery. After this, the portions of the metallic wire-gauze, or other material, which may happen to project beyond the edges of the aforesaid hoop or ring, are to be cut off all round evenly, and a small ornamental band of metal, or other material, may be soldered or otherwise fixed upon the exterior edge of the article, so as partly to conceal the interior hoop or ring, and render the whole neat; and then, to finish and complete it, a small nut or button may be fixed through the aperture in the crown, for the convenience of carrying the articles by. Articles of this description will be found very serviceable for covering up delicate commodities, or articles of food, to preserve them from the effects of flies, and for a great variety of useful purposes."

The specification then proceeds to describe another slight variation from the above method, for "producing articles of such a description as will not admit of a hole or aperture being made in them." For this purpose, the actuating screw is made to pass through a fixed nut in an iron frame, the end of the screw entering the flat or lower side of the block, which is forced into the cavity of the mould, with the wire-gauze between them. The patentee concludes by claiming as his invention, "the forming or producing of articles of various shapes,

patterns, and sizes, out of metallic wire-gauze, or other materials, as aforesaid, by the operation of pressing or forcing the said metallic wire-gauze, or other materials, into moulds or shapes of the desired form of the article intended to be produced; the articles so formed or produced from the metallic wire-gauze, or other material, being caused to retain or preserve the shape or pattern which may have been given to them, by means of one or more hoops or rings, which are secured by solder or otherwise to the edges of the said articles, during the time they remain within the mould."

WOOD. The ligneous matter forming the substance of trees. It is, in most cases, possessed of colour, taste, and smell, from the presence of extractive matter, mucilage, resin, or essential oil; and it is only when these have been extracted by water and alcohol, that wood can, as a chemical principle, be regarded as pure. In this state, it is insoluble in water: it is equally insoluble in alcohol, and hence it forms the residuum, when any of the solid parts of plants have been acted on by these fluids. From the action of the air, if dry, it does not appear to suffer any change; but, when humid, it is gradually decomposed, and passes through many intermediate states, to that of a black mould, consisting principally of carbon. The oxygen of the atmospheric air is, during this change, absorbed, and carbonic acid formed with a portion of water; and the latter, being derived from the combination of the oxygen, leaves carbon predominant. When the air is entirely excluded, wood decomposes with extreme slowness, even though humid; as, for example, when it is buried in the earth, the alkalies act on wood, and stain it of a dark colour: with the assistance of heat, they soften, and partly dissolve and decompose it. The stronger acids act on it. Sulphuric acid carbonizes it, rendering it speedily black and soft. Nitric acid gives it a yellow tinge, and, when acted on in large quantity, disengages nitrogen gas, and converts it into oxalic acid, with small quantities of malic and acetic acids.

Wood suffers decomposition from heat; a large quantity of an acid liquor distils over, with a portion of empyreumatic oil. Carburetted hydrogen and carbonic acid gases are disengaged, and a portion of ammonia is produced, which is neutralized by the acid. A charcoal remains, which retains the figure and even texture of the wood. The acid procured in this process, was observed to be similar to vinegar, and was afterwards regarded as a peculiar one, and named pyro-ligneous acid; but the researches of Fourcroy and Vauquelin proved that it is only acetic acid, with an impregnation of empyreumatic oil.

When air is admitted, and the heat raised to ignition, wood burns. Its combustion at first, gives much light, from the formation and extrication of carburetted hydrogen: this soon ceases, and the charcoal remains, which burns with its usual red light. The products of the combustion are principally carbonic acid and water. Nitrogen appears to be a constituent principle of wood; ammonia, therefore, is also evolved, and accordingly, an ammoniacal salt is found in the soot of wood.

The colouring of wood is effected by a variety of processes. Stains do not lie, like paints, upon the surface of wood, but sink more or less into its substance. Hence, the material which has been stained, exhibits its natural grain and hardness: and it must be remembered that, if the wood be not white, the colour taken will be a compound of that of the wood and the stain. The dyeing woods employed, are in small chips or raspings.

The woods which have been stained are afterwards rubbed up with rushes, then with a cloth, dipped in a solution of bees' wax in spirits of turpentine; and afterwards rubbed with a woollen cloth alone. When the stain is intended to be very deep, the pieces should be boiled in the staining liquor, and not merely brushed over. To stain wood red, take two ounces of Brazil wood, and two ounces of potash; mix them with a quart of water, and let the composition stand in a warm place for several days, stirring it occasionally. With this liquor, made boiling hot, brush over the wood till the desired depth of colour is obtained: then with another brush, brush over the wood while yet wet, with a solution of alum, in the proportion of two ounces of alum to a quart of water. For a pink or rose red, use double the quantity of potash. For a less bright red, dissolve

an ounce of dragon's blood in a pint of spirits of wine, and brush over the wood with the tincture till the stain appear to be as strong as is desired; but this is, in fact, rather lacquering than staining. For a pink or rose red, add to a gallon of the above infusion of Brazil wood two additional ounces of the pearl-ashes, and use it as was before directed; but it is necessary, in this case, to brush the wood over with the alum-water. By increasing the proportion of pearl-ashes, the red may be rendered yet paler; but it is proper, when more than this quantity is added, to make the alum-water stronger. To stain wood green, dissolve verdigris in vinegar, or crystals of verdigris in water, and brush over the wood with the hot solution. To stain wood blue, dissolve copper in diluted nitric acid, and brush it while hot several times over the wood, then make a solution of pearl-ashes, in the proportion of two ounces to a pint of water, and brush over the stain made with the solution by copper till the colour be perfectly blue. The green stain, made as above with verdigris, may be changed to a blue, by the solution of pearl-ashes. The sulphate of indigo, which may be had, ready prepared, of the dyers, will, when diluted with water, make a blue stain. To stain wood black, brush the wood several times with a hot decoction of logwood, then several times with common ink. To make a very fine black, brush over the wood with a solution of copper in nitric aid as for blue, and afterwards with logwood, till all the greenness of the copper solution is gone. To stain wood purple, take one ounce of logwood and two drachms of Brazil wood; boil them together in a quart of water, over a moderate fire. When one half of the fluid is evaporated, strain the decoction, and brush it several times over the wood. After the wood is dry, brush it over with a solution of a drachm of pearl-ashes in a pint of water.

WOOL. The long, soft, curly hair, which covers the skin of sheep, and some other ruminating animals. Wool resembles hair in many respects; besides its fineness, which constitutes an obvious difference, there are other particulars which may serve also to distinguish them from one another. Wool, like the hair of horses, cattle, and most other animals, completes its growth in a year, and then falls off as hair does, and is succeeded by a fresh crop. It differs from hair, however, in the uniformity of its growth, and the regularity of its shedding, the whole crop springs up at once, and the whole falls off at once, if not previously shorn, which leaves the animal covered with a short coat of young wool, which in its turn undergoes similar mutations. Berthellot has shown that the caustic alkaline leys dissolve wool entirely, and that the acids precipitate it from this solution. The facts elicited by chemical research explain all the phenomena, and all the properties which wool presents in the frequent and advantageous uses to which it is applied. While the wool remains in the state in which it is shorn from the sheep's back, it is called a fleece. Each fleece consists of wool of different qualities and degrees of fineness, which the dealers sort and sell in packs at different rates to the wool-comber. The finest wool grows on and about the head of the sheep, and the coarsest about the tail; the longest on the flanks, and the shortest on the head and some parts of the belly. Wool that is shorn when the sheep is living, is called fleece wool, and that which is pulled off the dead animal is called skin-wool. Wool, in the state in which it is taken from the sheep, is always mixed with a great deal of dirt and foulness of different kinds, and in particular is strongly imbued with a natural strong-smelling grease. These impurities are got rid of by washing, fulling, and combing, by which the wool is rendered remarkably white, soft, clean, light, and springy. When boiled in water for several hours, it is not altered in any sensible degree, nor does the water acquire any impregnation.

The wool intended for the manufacture of stuffs is brought into a state adapted for the making of worsted by the wool-comber; who, having cleansed it from all impurities, and well washed it with soap and water, he puts one end of a certain quantity on a fixed hook, and the other on a moveable hook, which he turns round with a handle, till all the moisture is forced out. It is then thrown lightly into a basket. The wool is next spread out in layers, and a few drops of oil are scattered on each; which are packed in a bin underneath a bench where the comber sits at work. At the back of the bench is another bin, to

contain the *noyles*, as it is called, which is that part of the wool that is left in the wool after the sliver is drawn out. The comb consists of three rows of highly-tempered and polished steel, fixed in a long handle of wood, and set parallel to one another. Each comber has two combs, which he fills with wool and then works them together, till the wool on each is perfectly fine, and fit to draw out in slivers. The best combs of this kind are said to be manufactured at Halifax, in Yorkshire. In using these combs the workman has a pot made of clay, with holes in its side, in which he heats them to a certain temperature before it can be made readily to pass through the wool. Each comb-pot is made to hold eight combs, so that four men usually work in one compartment of the shop, round a single pot. When the wool has been sufficiently worked on the combs, the workman places one comb and then the other on a fixed spike, at a proper height for him to draw it out as he stands. The wool thus drawn out is called a sliver, and is from five to six or seven feet in length. Such is the mode of wool-combing by hand, but several patents have been taken out for performing the same operation by machinery; the first of which was introduced by the ingenious Dr. Cartwright, in 1790, and wool-combing by machinery has now almost wholly superseded the work by hand, owing to the economy of labour and material which it effects.

The manufacture of wool is divided into two distinct classes,—long wool, or worsted-spinning, and short wool, or woollen-yarn-spinning. We have already described, under COTTON, the process of spinning that material: it will be readily conceived that the spinning of other fibrous matter does not very essentially differ therefrom, but that it merely requires certain modifications in the apparatus to adapt it to the difference of fibre in the staple commodity. In spinning *worsted* by hand, the portion of wool plucked from the sliver was placed across the fingers of the left hand, and from the thick part of it the fibres were drawn and twisted as the hand was withdrawn from the end of the spindle, to which it had been previously attached. The revolution of the wheel, effected by the right hand, conveyed by a band to the wheel, or pulley on the spindle, produced the requisite to give firmness to the thread; and by a very gentle motion of the same wheel, the thread being brought nearly perpendicular to the spindle, it was wound upon the spindle to form the cop. From this it was transferred to the reel, and became a hank, of a definite length, but varying in weight with the thickness of the thread. In this state it was transferred to the manufacturer, to be converted into shalloons, bombazin, or whatever other fabric *worsted* is applicable to.

"A few years after the introduction of cotton machinery," (says the author of the *Operative Mechanic*), "an obscure individual of the name of Hargraves, previously unknown as a mechanic, who had long been employed by Messrs. W. Birkbeck and Co. of Settle, in Yorkshire, in the management of a branch of the worsted manufactory, attempted to spin long wool by means of rollers. He constructed working models of the necessary preparing machinery, and of a spinning frame, by the assistance of persons accustomed to the construction of cotton machinery; and succeeded so completely, as soon to induce his employers to build a large mill for its application. By degrees his plans became known to the trade, and many large manufactories have subsequently been erected for this purpose. Contrary to the earlier anticipations on this subject, it has been found that mill-spun yarn answers better for the coarse as well as the finer fabrics, than that produced by the hand, which it has entirely superseded."

In spinning worsted by machinery, a sliver of wool is laid upon the drawing-frame, from whence it is conducted through several pairs of rollers, of which the operation of the first and last are the essential ones, the intermediate rollers moving with equal velocities, and serving merely to conduct the skin, which is received into a cylindrical can; three such skins being passed through another drawing-frame, and stretched in their progress, become fitted for roving,—the last step in the preparatory process. The spinning, which is the concluding process, is effected by means of two pair of rollers moving with equal velocities, and intermediate auxiliaries.

In manufacturing short wool into *cloth*, it is first soaked in urine, and

frequently rinsed in clean water, which adapts it to the next operation,—that of carding. The carding engine for fine short wool is constructed with one main cylinder, having in lieu of the top cards used in jenny-spinning, numerous small rollers, lying and rolling upon its upper surface; it is used in place of a breaker engine, and is called a scribbler. The wool is delivered from a main cylinder to a doffer, and, being combed or doffed, is carried to another engine called the *carder*, which perfects the carding, and delivers it off, by means of grooved mahogany rollers, in a row or rowan, as in jenny-spinning. If the wool is of a coarse description, such as is formed into yarn, for the manufacture of coarse cloths, more carding is required.

The *scribble* engine has three distinct parts or cylinders in one frame. The first part consists of the first main cylinder with its top rollers, and is called the breast; this delivers the wool to the second main cylinder, which with its top rollers is called the first part; this delivers it up to a small intervening cylinder called the tween doffer, which carries it to the third main cylinder, which, with its top rollers, is called the second part; from hence it goes to the last doffer cylinder, from which it is combed by a doffing-plate, and finally carried in hand to a carding engine; by which the wool is formed into separate and smooth rolls of twenty-eight inches long, and half an inch thick, which are immediately taken by boys, and attached to the spindles of the roving or slubbing machine. This machine draws out the wool into large and slightly twisted threads, and winds it into balls ready for spinning. By the spinning jenny the threads are twisted, and drawn to a proper degree of size and strength, and are then reeled into skeins and prepared for the loom. The stronger sort intended for the woof is wound on spools, or quills, which are tubes of such a size and shape as to be easily placed in the hollow of a shuttle. That designed for the warp is wound on large wooden bobbins, from which it is by the warping-bar conveniently arranged for the chain or warp of the piece.

A patent was taken out a few years since, by Mr. Hadden, for improvements in preparing wool, and also for roving and spinning it in a heated state. The patentee observes, that various methods may be adopted for supplying heat to wool, during all or either of the three processes of preparing, roving, and spinning. The method which Mr. Hadden has adopted is the introduction of cast-iron heaters into the retaining rollers used for these processes, observing that he always uses three rollers or cylinders together, and by leading the wool over half the circumference of the upper two rollers, charged within with the heaters above mentioned, he thoroughly warms the wool, without retarding the progress of the other presses.

The mode of applying the heaters is by making the retaining cylinders hollow, and by introducing a cylindrical heater into each retaining cylinder. These heaters are made exactly to fit the interior of the retaining cylinders, the axes of which pass through a channel for that purpose in the middle of the heater. It is to be observed that the heaters may be put within the driving cylinders with equal effect.

The qualities which distinguish woollen cloths from all other manufactures, and renders them particularly suitable for northern climates, are the compactness and density they acquire from the operation of fulling. The cloth is sprinkled over with a liquor prepared from oil of olive soap dissolved in hot water, and then laid in the mill-trough, where it is pounded with heavy wooden hammers. By this process a cloth 40 yards long, and 100 inches wide is reduced to 30 yards long, and 60 inches wide. During the operation the cloth is taken from the trough, the wrinkles smoothened, and more soap added. The property of becoming thicker by compression is peculiar to woollen cloths. It is said that the fibres of the wool are thickly set with jagged protuberances, which it is supposed catch hold of each other when pressed together, and thus become inextricably united, so that the cloth when cut does not unravel like other cloth. After milling, the cloth is scoured with a preparation of fuller's earth and bullock's galls, till perfectly free from soap, and then taken to the cloth-worker to be dressed. This operation is performed by first drawing out and placing in one direction, by means of wire cards and teazles, all the fibres of

wool that can be brought to the surface, and then shearing them as close as may be practicable without laying the threads of the cloth bare. The instruments employed in this process were formerly worked by hand; but this operation is now performed by machinery, in a very superior manner to any manual efforts, and at a much less expense. When this process is completed, the cloth is taken to the rack, where it is strained so as to bring it to an even breadth throughout its length, and it is then sheared again, to render it perfectly level and uniform. All the little bits of straw or lint that may adhere to it are now picked out, and any holes that may be discovered carefully fine-drawn. The cloth is next laid in a press with a sheet of glazed paper between every fold; these are covered by thin boards, and hot iron plates laid thereon, by which a gloss is communicated to the cloth. After the press has been screwed down for a sufficient time, the pressure is removed, and the cloth taken out and packed for sale.—We have thus given an outline of the process of manufacturing of woollen cloth, as it was generally conducted a few years ago: but the rapid progress of mechanical invention during a very brief period, has made so extensive a change in the apparatus and processes, as to preclude the possibility of a detailed description within the prescribed limits of this work; we shall, however, before closing this article, notice two or three recent patents, the leading objects of which are to give to woollen cloths that silky softness and gloss, for which the best finished modern fabrics are so distinguished.

Mr. Fussel's mode of producing the lustre upon cloths, as stated in the specification, is in substance as follows.—After the cloth has undergone the usual dressing in the gig-mill, and hand-brushing, it is to be tightly wound upon a cylindrical roller, the extremities of which are to have deep grooves made round their peripheries, that will permit the list on the edges of the cloth to sink into them, and by these means preserve the cloth in a smooth and level surface. The roller of cloth so prepared is to be set on end for some time, to permit the water to drain off; it is then to be placed in either an open vessel over a steam boiler, and exposed to the action of the steam for three hours, or it may be placed in a close vessel into which the vapour is to be allowed to pass while it is made to revolve. The temperature of the steam proper to be employed depends upon the colour of the cloth, and the degree of lustre required; but in general the heat should be somewhat less than that of boiling water.

Mr. James Dutton's patent method consists in pressing the cloth at the time it is being heated. His press for this purpose has one fixed, broad, and flat surface or table, equal to the whole width of the cloth, and of suitable dimensions in the other direction to receive about a yard of the cloth in length at a time, to receive the pressure; which is effected by a flat metal plate, or platten, of corresponding dimensions, made to rise and fall, and to be operated upon by powerful leverage, or hydrostatic pressure. To render the effect of this process permanent, heat and humidity are employed in conjunction with it. For this purpose a steam or hot-water chamber is formed in the table of the press, and the cloth is brought under the operation in its wet state, the pressure being continued upon each successive portion of cloth, for a certain number of minutes (varying with the "dress" required, and other circumstances).

It is desirable, in the process of roughing or raising the pile upon woollen cloth, that the action of the teazles should be made to deviate from straight lines on the surface of the cloth. The patented improvement of Mr. Oldland, dated July 1830, for this object, consists in a horizontal revolving teazle frame, furnished on its under side with teazles, wire-cards, brushes, or other materials used in dressing or raising the pile of the cloth. The revolving teazles are put in motion by a band fixed to the revolving spindle; and as the cloth is brought under the teazles by conducting rollers of the usual construction, it is pressed up against the teazles by a supporter covered with some elastic material, only on that side of the centre of motion of the revolving teazle which moves from the middle towards the selvage of the cloth, the teazle frame reaching only halfway across it; and one being placed on each side, moving in different directions, the pile will be raised in all cases from the centre towards both selvages of the piece of cloth, though from the nature of the action of this machine it is evident that its operation

on the cloth can in no case be rectilineal, and that by the end motion of the cloth the lines of action will be continually crossing each other at very acute angles. In the same year another patent was taken by Mr. Papps, for the same object, in which the principle and operation are the same, though the details vary a little. A third patent for the same object was granted on the same day as the last mentioned, to Mr. Ferrabee, who raises the pile in a different direction, namely, from the middle sloping to the sides; for this purpose he employs two series of teazles; each series is attached to an endless chain which passes round two cylinders by which it is put in motion. Two of the cylinders which support and give motion to the teazle chains are placed with their axes extending along the middle of the piece of cloth to be operated upon, and the other two cylinders are placed near the selvages of the cloth, with their axes parallel thereto. Each pair of cylinders is made to turn in a direction to raise the pile of the cloth from the middle towards the selvages, at right angles to them when the cloth is at rest; but when an end motion is given to the cloth, which is effected by means of two cylinders placed at right angles to the teazle cylinders, the pile is raised in an angular direction, sloping from the middle towards the selvages. The angle of the work may be varied at pleasure, by varying the relative speeds of the different sets of cylinders.

The processes employed in dyeing woollen cloth differ considerably from those used in silk and cotton. The oil is first removed by the operations of the fulling-mill, where it is beaten with large beetles in troughs of water, mixed with fuller's earth; and when thoroughly cleansed it is ready for dyeing. The only colours used in dyeing wool *blue*, are woad and indigo, which are both substantive colours, that is, they are permanent without requiring a mordant. Quatremere recommends the following mode of preparing a blue vat:—Into a vat about seven and a half feet deep, and five and a half broad, are thrown two balls of woad, weighing together about 400 lbs., first breaking them; thirty pounds of weld are boiled in a copper for three hours, in a sufficient quantity of water to fill the vat; when this decoction is made, twenty pounds of madder and a basket full of bran are added, and it is boiled half an hour longer. The bath is cooled with twenty buckets of water; and, after it is settled, the weld is taken out, and it is poured into the vat; all the time it is running in, and for a quarter of an hour after, it is to be stirred with a rake. The vat is then covered up very hot, and left to stand six hours, when it is raked again for half an hour, and this operation is repeated every three hours. When blue veins appear on the surface of the vat, eight or nine pounds of quick lime are thrown in. Immediately after the lime, or along with it, the indigo is put into the vat, being first ground fine in a mill, with the least possible quantity of water (it is now usually ground dry.) When it is diluted to a semi-fluid consistence, it is drawn off at the lower part of the mill, and thrown thus into the vat. The quantity of indigo depends upon the shade of colour required. From ten to thirty pounds must therefore be put to the vat now described, according to the occasion.

If, on striking the vat with the rake, a fine blue scum arises, it is fit for use, after being stirred twice with the rake in six hours, to mix the ingredients. Great care should be taken not to expose the vat to the air, except when stirring it. As soon as that operation is over, the vat is covered with a wooden lid, on which are spread thick cloths, to retain the heat as much as possible. Notwithstanding this care, the heat is so much diminished at the end of eight or ten days, that the liquor must be re-heated, by pouring the greater part of it into a copper over a large fire; when it is hot enough, it is returned into the vat, and covered as before.

This vat is liable to two inconveniences: first, it runs sometimes into the putrefactive fermentation, which is known by the fetid odour it exhales, and by the reddish colour it assumes. This accident is remedied by adding more lime. The vat is then raked; after two hours, lime is put in, the raking performed again, and these operations are repeated till the vat is recovered; secondly, if too much lime is added, the necessary fermentation is retarded; this is remedied by putting in more bran or madder, or a basket or two of fresh woad.

When cloth is to be dyed, the vat is raked two hours before the operation; and to prevent it from coming in contact with the sediment, which would cause inequalities in the colour, a kind of lattice of large cords, called a cross, is introduced; when unmanufactured wool is to be dyed, a net with small meshes is placed over this. The wool or cloth, being thoroughly wetted with lukewarm water, is pressed out, and dipped into the vat, where it is moved about a longer or shorter time, according as the colour is intended to be more or less deep, taking it out occasionally to expose it to the air, the action of which is necessary to change the green colour, given the stuff by the bath, to a blue. Woollen and cloth dyed in this manner ought to be carefully washed, to carry off the loose colouring matter; and, when they are of a deep hue, soap should be used, as it will only cleanse and not injure the colour. The more perfectly the wool has been scoured, the better it will receive the dye.

A vat which contains no woad, is called an indigo-vat. For this vat, the indigo is rendered soluble in water by potash instead of lime; a copper vessel is used, and six pounds of potash, twelve ounces of madder, and six pounds of bran, are boiled with every 120 gallons of water; six pounds of finely-ground indigo are then added, and, after carefully raking it, the vat is covered, and a slow fire kept round it. Twelve hours afterwards, it is to be raked a second time, and this operation is to be repeated at similar intervals of time, till the dye becomes blue, which will generally happen in forty-eight hours. If the bath be properly managed, it will be of a green colour, covered with coppery scales, and a fine blue scum.

The dye called *Saxon blue* is made with the solution of indigo in sulphuric acid. Take four parts of sulphuric acid, and pour them on one part of indigo, in fine powder; let the mixture be stirred for some time, and after it has stood twenty-four hours, add one part of dry potash; let the whole be again well stirred, and after it has stood a day and a night, add gradually more or less water. The cloth to be dyed, must be prepared with tartar and alum, and more or less indigo must be put into the bath, according to the shade required. For deep shades, also, the cloth must be passed several times through the bath; light shades may be dyed after deep ones, but they will not have the lustre given by a fresh bath.

Reds are a very important class of colours, and are furnished by a great number of substances. They all depend, either for their fixedness or beauty, upon the use of mordants; the principal of them are kermes, cochineal, archil, madder, carthamus, and Brazil-wood. Pewter boilers, or well-tinned copper, must be used in preparing all red baths.

The shades of red are usually distinguished into three classes; namely, the madder red, crimson, and scarlet. Madder is employed for coarse goods. It gives out its colour to water; and the bath prepared with it is not made hotter than what the hand can bear, until the wool has been in it about an hour, when it may be boiled for a few minutes just before the wool is taken out. It may be used in the proportion of one-third or one-fourth of the wool dyed. Cloths are prepared for the madder-bath, by boiling them for two or three hours in a solution of alum and tartar; after having been taken out of which, they are left to drain for a few days in a cool place before they are dyed. The use of archil gives a fine but transient bloom to the madder dye. Archil and Brazil-wood, from their perishableness, are seldom used to wool, except in this way, as auxiliaries.

When sulphate of copper is employed as the mordant, madder dyes a clear brown, inclining to yellow. Tin brightens its colour, but not materially.

Kermes has not been much used since the art of brightening cochineal with tin was discovered, as it has not so fine a bloom as the latter dye, though it possesses greater durability. Kermes imparts its colour to water; and the quantity of it used, is, for a full colour, at least three-fourths of the weight of the wool employed. The wool is put in at the first boiling, after having been previously prepared by boiling it for half an hour in water with bran, and afterwards two hours in another bath, with one-tenth of tartar dissolved in sour water, and then leaving it for a few days in a linen bag.

The red colour of the flowers of carthamus is extracted by a weak alkaline ley, and precipitated by lemon juice or sulphuric acid, but is chiefly used for silk and cotton. The precipitate is used in dyeing, and is called *safflower* or *bastard saffron*.

A crimson colour, inclining to violet, is the natural colour of cochineal, which yields most of its colouring matter to water, and, by the addition of a little alkali or tartar, the whole of it is extracted. To dye crimson by a single process a solution of two ounces and a half of alum, and an ounce and a half of tartar, with an ounce of cochineal, is employed for every pound of stuff. A little muriate of tin must be added for a fine crimson. Archil gives to crimsons that fine dark shade which is called bloom, but this soon disappears, by exposure to the air and light. For pale crimsons, the quantity of cochineal is reduced, and madder substituted.

Dr. Bancroft first suggested that scarlet was a compound of crimson and yellow, and he founded upon this idea, a more economical mode of producing it than had previously been used. He gives the following directions for dyeing scarlet:—One hundred pounds of cloth are to be put into a tin vessel, nearly filled with water, with which about eight pounds of the murio-sulphuric solution of tin have been previously mixed. The liquor is made to boil, and the cloth is turned through it by the winch, for a quarter of an hour, in the usual manner. The cloth is then taken out, and four pounds of cochineal, with two pounds and a half of quercitron bark in powder, put into the bath and well mixed. The cloth is then returned into the liquor, which is made to boil, and the operation is continued as usual, till the colour be duly raised, and the dyeing liquor exhausted, which will usually happen in about fifteen or twenty minutes, after which, the cloth may be taken out and rinsed. In this method, the labour and fuel necessary in the common process for the second bath are saved, the operation is finished in much less time; all the tartar will be saved, as well as two-thirds of the expense of the solvent for the tin, and at least one-fourth of the cochineal usually required; the colour, at the same time, will not be in any respect inferior to that produced in the ordinary way, at so much more trouble and expense, and it will even look better by candle-light than others.

By omitting the quercitron-bark, the above process will afford a rose-colour. Scarlet may be changed to crimson by boiling the cloth in a solution of alum till the shade desired is obtained. Alkalies and earthy salts in general have the same effect as alum.

Yellow is a colour but rarely required in the dyeing of wool, yet, as it frequently forms the base of other colours, it may be proper to notice it. Weld, fustic, and quercitron bark, furnish the best yellows: weld is a plant which is both cultivated and grows wild in this country; the stem is slender, and rises to the height of three or four feet; the entire plant is used in dyeing, and is gathered when it is ripe: the shortest and slenderest stems are the most esteemed. Fustic is the wood of a large West Indian tree. Quercitron grows in great abundance in North America, and is there called yellow oak; its bark is the only part used for dyeing.

The colours obtained from weld and quercitron both nearly resemble each other in shade, and also in durability, which is not great; but the bark containing the largest quantity of colouring matter is not only the most convenient to use, but upon the whole the cheapest. Dr Bancroft has given the best directions for its use. He directs a deep and lively yellow to be thus prepared for wool:—Let the cloth be boiled for an hour or more, with about one-sixth of its weight of alum dissolved in a sufficient quantity of water; then plunge it without rinsing into a bath of warm water, containing in it as much quercitron bark as equals the weight of the alum employed as a mordant. The cloth is to be turned through the boiling liquid until it has acquired the intended colour. Then a quantity of clean powdered chalk, equal to the hundredth part of the weight of the cloth, is to be stirred in, and the operation is completed. The object which the dyer has in view is to give his stuffs a uniform and durable colour, at the same time that he entirely preserves their original texture. He therefore uses colours in solution, in order that their particles may apply them-

selves to the individual fibres of the stuff, according to their affinity for it. When, for example, a quantity of wool, freed from all impurity, is dipped into the solution of any colouring matter, if the fibres of the wool have a stronger attraction for the colouring matter than the water or other menstruum which holds that colour in solution, the colouring matter will leave its solvent, and apply itself to the wool, which will by that means be dyed; its fibres will have become covered with colouring matter; and if their attraction for it be so strong that the action of soap, air, and light, or other ordinary means of exposure, shall have no perceptible effect in decomposing the combination, or in other words, of injuring its tinge, the colour is said to be permanent; so that dyeing is in fact a chemical process, and the application of both animal and vegetable bodies depends on their chemical affinities.

WRITING. The art of communicating our ideas to others by means of inscribed signs or characters. Amongst the various arts which have from time to time contributed to the improvement and advancement of society, there is, perhaps, none which, in point of utility and excellence, will at all admit of comparison with the art of writing. Yet because this art may now be acquired by every body, it fails to attract the attention and command the admiration it so well merits. How curious and beautiful soever a new discovery may be, let it once become common, and from that moment it ceases to be noticed; that which is within the grasp of every body is despised. The time was, when a man who could write was highly distinguished amongst his fellows; but the time is approaching, when a man who cannot write will be pointed out as a remarkable character.

In the first ages of the world, while society was in its infancy, mankind had clearly no other method of expressing their ideas in writing, than the simple one of making a figure of the shape of the object. And this method must have been long before their dispersion; for it has been found to exist amongst the most rude, as well as the most polished nations of the globe; situated too at such remote distances from each other as to preclude intercourse with the rest of mankind. This mode of writing seems the most natural, because the representation of sounds, which express the names of things, by certain characters or alphabets now so extensively in use, must necessarily require some previous concert between two parties, the one of whom suggests, and the other agrees, that a particular mark or form on paper, shall be the symbol for a particular sound. But if we suppose a savage separated from his friend, and wishing to communicate with him, without having had this previous consultation, and supposing that he has lent his distant acquaintance some articles of furniture, such as his bow and arrows, or his knife, which he is anxious to have returned, without the knowledge of his messenger, or being dependant upon his memory; it seems highly probable, that his first impulse would be to make a rude sketch of these articles, and transmit them to his friend. Were the latter an acute man, he would probably understand the allusion; and were he not intelligent enough for this purpose, it is clear he would not be sufficiently so to comprehend symbols that denote sounds. So that the simplicity of this mode of writing might suggest the probability of its being first resorted to, without alluding to the hieroglyphics yet remaining on the Egyptian tombs, which, from our want of acquaintance with the manners, customs, and general objects with which the Egyptians were conversant, are very difficult to decipher, if we may judge from the learning displayed in explaining them. In *Freycinet and Arago's Voyage* is given the drawing of a letter, written in this kind of language, from an inhabitant of the Caroline Islands to M. Martinez, which is perfectly intelligible. M. Martinez had commissioned a Tamor of Sathoual to send him some shells, promising in exchange a few pieces of iron. The captain gave him a sheet of paper, on which he sketched with a red pigment, first, in the middle of the top of the page, a small figure of a man with his arms extended horizontally, intended to represent the bearer of compliments; and underneath the man, the branch of a tree, as the type of peace and amity. On the left hand side were represented the forms of nine different shells the Carolinean had to send; and on the right hand side were delineated the objects he desired in exchange; namely, three large fishing-

hooks, four small ones, two axes, and two longer pieces of iron. The barter was accomplished to the satisfaction of both parties. This is, perhaps, as clear an instance as can be found, of the mode in which an unlettered people would endeavour to convey the expression of their wishes to their friends at a distance, and forms a striking contrast to the elegant though complicated process of our own method of writing.

The written language of the Chinese affords many proofs of its having originated in picture writing. This method of writing, of course, required considerable patience and skill to practise, and by common consent the characters or signs were from time to time simplified, so as to be expressed by much fewer lines. In Egypt, where the progress of the arts was greatly encouraged, means were discovered to substitute the original figures by very simple marks, by retaining only the most prominent peculiarities of the objects, and these, from their superior convenience and facility of execution, soon afterwards became universally adopted. Yet it may be readily conceived, that there remained many difficulties to overcome, by the great variety and intricacy of the figures. To simplify, therefore, the method of writing still further, the priests turned many of the outlines into arbitrary marks, which in course of time so deviated from their originals, as to render it almost impossible to trace them to their archetype, but which were nevertheless much less complicated and more expeditious. Thus, after incredible labour, through the lapse of many ages, were produced the three different modes of writing among the Egyptians, designated by the appellation of *hieroglyphic*, *demotic*, and *hieratic*. Into the nature of these our limits do not permit us to enter; but they constitute a subject well worthy of attention.

The next step of improvement was to form a connexion between the object represented, and the *sound* of the word used to express it. Nor was this so difficult as would at first sight be supposed: for when a man represented any image or picture, that of a "door" for instance, he would naturally give to the combination of lines with which that figure was formed, the name of a "door," and wherever he met with this representation, or even though he should change it for some arbitrary and more simple mark, having the same signification, the same name would still remain attached to it, and by this means the word *door* would for ever afterwards remain associated with a certain outline or figure. The Hebrew alphabet affords a most satisfactory illustration of this. Every letter is, in fact, a word, and expresses some simple object. *Deleth*, for example, their fourth letter, corresponding with our D, signifies a "door;" *Beth*, their second letter, answering to our B, "a house," and in this manner each of the remaining letters of the alphabet have a meaning attached to them. Having attained this state of advancement, the progress of the art was more rapid. Every nation, in its turn, contributed some letters to the common stock; in a happy moment it was discovered, that each monosyllable terminated by a sound which, with very little variation, was repeated in all. Nor was it difficult to ascertain the number of these which were invariably fixed to the four or five inflexions of voice. Thus were vowels added to consonants, and mankind gradually arrived at the greatest of all inventions,—the invention of the alphabet. But who was the man, or what his nation, to whom the honour of this invention is due is still disputed by the learned, though the majority agree in considering the presumption to be strongest in favour of Thoth, a son of Mizraim, the father of the Egyptians.

This noble invention diminished to a prodigious extent the difficulty of writing, it shortened the labour of memory, and was capable of expressing all subjects, and all ideas. The Phœnicians obtained a knowledge of the system, imparted it to the Greeks, whence it was gradually spread over the continent to our islands, and was at length diffused over the whole world. The first substance used for writing upon is considered to have been dried leaves; but there is much evidence to show, that plates of brass, lead, wood, stone, ivory, and wax, were also used. The ancients generally used tables covered with a coat of wax, on which they wrote with a *style*, a piece of iron pointed at the end, with which they made the letters, and blunt or flat at the other end, which they used for rubbing out what they had written, either when they wished to make any alteration or to use the table for other writings. By a good or bad *style*, therefore, they meant

at first simply to denote the quality of the instrument with which they wrote. The term was afterwards applied metaphorically to the language. in which sense it is now used.

Among the different substances that were employed for writing upon, before the art of making paper from linen-rags was discovered, we find the earliest to have been these tables of wood, made smooth, and covered with wax. But as what was written on wax might easily be defaced, leaves of the *papyrus*, a kind of flag, which grew in great abundance in the marshes of Egypt, were dried, and by a particular process prepared for writing. Sheets were also separated for the same purpose from the stem of the plant. On these, the letters were engraved with an instrument similar to that used for writing on wax. The substance so prepared was called *charta*, from a city of Tyre of that name, near which the plant was also found. The words folia, *leaves*, and *charta paper*, thus derived, are well known among ourselves.

As in writing a treatise, a great number of these leaves or sheets was required, they were joined together by making a hole and passing a string through each of them. With the same string passed several times round them, they were confined, to prevent their separating, and being injured or lost when no one was reading them; whence it is supposed that a roll or bundle of them obtained the name of a volumen, or *volume*. Those who have seen specimens of the Burmese writing on leaves thus collected, may form an accurate notion of an ancient papyrus volume.

Another article used for writing, was the inner bark of certain trees. This was prepared by beating it, and then cementing it together by a solution of gum. As the inner bark of trees is called *liber*, the volumes of books were thence called *libri*, a name they still retain. Vellum, the last substance to be mentioned, is said to owe its origin to the following circumstance. Eumanes, King of Pergamus, being desirous of forming a library that should equal, or exceed in number the far-famed library of Alexandria, Ptolemy, King of Egypt, with a view of frustrating his design, prohibited the exportation of the papyrus. This excited the industry of some artists in the court of Eumanes: they contrived a method of preparing the skins of sheep, and it was called vellum, from vellus, a fleece or skin; and *parchment*, from Pergamus, the place where the art of preparing it was discovered: or, if not discovered, it was there improved, and first brought into general use.

The Greeks and Romans as well as most of the eastern nations adopted the form of the continuous roll. There were two rollers, one at each end of the roll, round one of which the whole manuscript was folded: the reader unrolled one end, and as he proceeded, he rolled it upon the empty roller until the whole was transferred from one roller to the other. Notwithstanding the great inconvenience which this contrivance inflicts upon readers, especially when they have occasion to refresh their minds by occasional references to passages lying under many coils of the roll, our Court of Chancery retains the "good old practice," for the purpose, it would almost appear, of deterring people from reading the specifications of patents and other public records. Persons who go to read these documents at the *Inrolment* Office, or *The Rolls* Chapel Office, should prepare themselves to have the sleeves and breasts of their coats grouted in by the lime dust by which the rolls of parchment are whitened!

Although much information upon the manners of the Romans has been obtained by the discovery of two Roman cities, which had been hidden by the cinders thrown from Mount Vesuvius, by the eruption about the year A. D. 79; but little more is known upon the subject of their books and manner of writing, than was known before the excavations. Rolls of brittle material, about eight inches long and about two inches in thickness, were frequently discovered by the workmen during the operations at Pompeii; but it was not first known that these were books: upon examination, however, they proved to be papyrus glued together. At one end of most of them was a label, upon which was written the title of the book, and the author's name. Of these rolls, Camillo Paderni carried away three hundred and thirty-seven, which he collected from the rubbish during twelve days which he passed among the ruins of Pompeii.

The papyrus has become so brittle, in consequence of the heat of the ashes, that no one has yet succeeded, to any extent, in unrolling them. Piassi, a monk, discovered a way of unrolling them, by putting thin slices of onion between the folds of the manuscript as he carefully separated them with a knife. This is the best contrivance which has yet been adopted, but it cannot be said to have proved successful. After all the time and money which have been bestowed upon this object, it is to be regretted that few works have been recovered. Some of these rolls are forty feet in length; many of them have been taken to the University of Cambridge, where they have remained many years, without any attempt having been made to unrol them.

The labour bestowed upon ancient manuscript books was immense. As they were intended to answer all the purposes of a modern printed book, their durability was of the greatest importance. The ancient copyists therefore paid great attention to the manufacture of their inks, as well as the parchment; in this art they were so successful, that most of the very ancient manuscripts which are now extant, are as legible, and the ink is as black and bright, as if they had been but just written. It is supposed that the ink owes this beautiful colour to the lamp-black. Some ink was found in a glass bottle at Herculaneum, which was very thick and oily. It was owing, perhaps, to its glutinous nature, that the persons employed to take down the speeches delivered by the orators in the Forum, preferred writing on waxen tablets, which required a very slight touch to mark them. It would have been an operation almost laborious to write with such ink as this found at Herculaneum, and the writer would have proceeded very slowly, and would not have been able to follow the speaker. There is one great objection to this ink; it does not enter sufficiently into the parchment, and is, therefore, easily obliterated. The Romans made ink of various colours; the emperors in the latter times, when wealth and luxury had destroyed the empire, endeavoured to make an appearance of grandeur, by writing with purple ink. Materials more valuable were sometimes used, when the writings were of value; the works of Homer were written in letters of gold, upon a roll 120 feet long, formed of the intestines of serpents. The Hebrews also are remarkable for the beauty of their manuscripts; the letters are as evenly formed as it would be possible to form them in a type; it is almost impossible to believe that they can have been written by a pen. All the eastern nations make their pens of reeds, which were well suited to the broad character of their writing; the reeds are brought from the East to Europe, and are used by the scholars in eastern literature; they are still used by many people in the East at this day. Reeds were used by other nations also. Pens made of them were discovered during the excavations at Pompeii; they are cut like a quill pen, except that the nib is much broader.

The quill pen appears to have been introduced about the year 600; the word *penna*, meaning a quill, is not found, it is said, in any work of an earlier period; previous to that date, the word *calamus* was used, which signifies a reed. Paper was introduced into Europe in the ninth or tenth century. It had previously been manufactured in China from a very remote period. About the year 716 a manufactory of it was established at Mecca, from whence it was brought by the Greeks to Constantinople.

We might have extended this article by some account of modern writing, but our space will not admit of it; and it is scarcely needful, as most of our readers are well informed upon the matter. We shall therefore conclude by a few remarks upon the peculiar direction of the writings of different nations. The Jews write from the right hand to the left; the Chinese from the top to the bottom; most other nations write as we do, from the left to the right.

X.

XEBEC. A three-masted vessel of a peculiar construction; chiefly employed in the Mediterranean. They are built extremely low, with a very convex deck, and carry a great press of sail. As the sea commonly breaks over the deck

they are provided with grated platforms at the sides, for walking upon. We have occasionally seen them in the Thames, employed as merchantmen, but their chief employment is in warfare.

Y.

YACHT. A sailing-vessel, fitted up with great elegance, and replete with conveniences. It is difficult to define any peculiarity belonging to them; as the term yacht is applied to so great a variety of forms; some represent complete three-masted *ships*, but of a diminutive size; while others are mere pleasure *boats*.

YARD. An English lineal measure, containing three feet, or thirty-six inches; also 1760 yards make a mile. The square yard contains $3 \times 3 = 9$ square feet: 4840 square yards are an acre, and 3,097,600 a square mile. The cubic or solid yard contains $(3 \times 3 \times 3) = 27$ cubic feet. The yard by which cloth is measured, is the lineal yard above-mentioned, but for convenience, divided into four quarters, or sixteen nails. This measure was instituted by Henry I. being the length of his own arm.

YARD. A long piece of timber or pole tapered towards each end, and suspended upon the masts of a vessel, to extend the sails to the wind.

YARN. Flax, wool, or other fibrous matter, spun into a loose thread; of which cloth or cordage is made. The process in preparing yarn, has been generally treated under the various substances of which it is formed. In this place we shall therefore confine our attention to yarn of a peculiar character, for which a patent was granted in 1832, to Mr. Greaves, of Chorley, in Lancashire. This invention consists in dyeing cotton in the wool, of various colours, and of every gradation of tint, and to mix the same up in various ways, with bleached white cotton, so as, by their union, to produce a self-varied colour of yarn, thread, or stuff, without such fabrics undergoing afterwards, as usual, the process of dyeing.

The patentee states his plan to be, to dye separate portions of cotton-wool of the seven primitive colours; and other portions of cotton-wool of various shades or tints of the foregoing; and with these, together with white cotton, according to the taste of the operator, to prepare yarn. Suppose, for instance, that the manufacturer required a peculiar green, he would take the primitive colours, yellow and blue, and mix them together in such proportions as would produce the exact tint desired, adding yellow to lighten, and blue to deepen the colour; if an orange, yellow and red; if purple, blue and red or pink; and by varying the nature and proportions of the combination of the primitive colours of the cotton-wool, and their several shades, every possible variety of tint, and every gradation of shade, may be obtained with the utmost facility.

When the due proportions of coloured cotton are put together, it is to undergo the same processes as if it were in a white state,—such as roving, spinning, twisting, winding, and doubling, to make it into yarn or thread, in which state it may be either used for sewing, embroidery, &c., or be woven into fabrics, as in other yarns, and will not require any subsequent operation, such as dyeing, beside avoiding the bleaching process, which is always liable to deteriorate the colour as well as the strength of the fabric.

A method of printing yarn was also patented by Mr. Schwabe, of Manchester, in 1831, which is described, with figures, in Hebert's "Journal of Patent Inventions," vol. vi. p. 171, which we have not space to insert.

YEAST. The scum thrown up in the fermentation of beer. See BARM, FERMENTATION, BREAD, and BEER.

YTTRIA. A peculiar substance discovered in 1794, by Gadolin: whether it be an earth or metal, the learned are not agreed. That great authority, Sir H. Davy, says that it consists of inflammable matter, metallic in nature, combined with *oxygen*. Its specific gravity is 4.842.

Z.

ZAFFRE. The residuum of cobalt, after the sulphur, arsenic, and other volatile matters of this mineral, have been expelled by calcination. The ores of cobalt are roasted in verberatory furnaces, provided with chambers to receive the arsenic: the product of zaffre is usually about 68 per cent. of that of the ore. The ores that contain much nickel are not fit for the preparation of zaffre, as the oxide of nickel would injure the beauty of the blue colour, or smalts, for the making of which zaffre is manufactured. Inferior kinds of zaffre are made by mixing this oxide, previously stamped and sifted to a fine powder, along with calcined flints or quartz, also ground in various proportions according to the use for which it is intended, moistening the whole with water, and packing it tight in casks, where it hardens to a stone. A very fine zaffre, or China blue, is obtained from the arsenical and grey cobalt ore, found in Cornwall, by boiling the powdered ore in nitric acid, which converts the arsenic into arsenical acid, and unites it with the different metals contained in the ore. The solution being diluted with a large quantity of water, purified pearl-ash water is then added in small portions to the diluted solution; and on the addition of each portion the liquid is well stirred, left to settle, and the clear part poured off. This is repeated until the solution becomes of a rose colour, which shows that it contains only the arseniate of cobalt. The pearl-ash water is then added in larger quantity than is necessary to throw down all it contains, and the solution is boiled for a few minutes. Being then left to settle, the liquid is filtered, the oxide of cobalt left on the filter, washed with boiling water, and dried. This oxide is then melted with feldspar and a little potash, and thus yields a beautiful zaffre for painting porcelain. Another method is to grind the ore, mix it with two or three times its weight of China ware, grossly powdered, and heat it very strongly. The whole is then put into three or four parts of nitric acid, diluted with an equal weight of water. The clear solution is poured off, evaporated gently to a syrupy consistence, diluted afresh with water, left to settle, poured off clear from the arsenic that is separated, and then the pearl-ash water is added by small portions, and the operation finished as in the former process. Zaffre is used for making smalts, and for painting on the best kinds of pottery. The common zaffre is cheap, but the best sells for two guineas the pound in the potteries. Zaffre is likewise used in the manufacture of cobalt.

ZEALAND (*New*) FLAX. The *phormium tenax* of naturalists. Its commercial name has been acquired from the circumstance of the natives of New Zealand employing it in the manufacture of their apparel, cordage, and all those purposes for which hemp and flax are used in other countries. The strength of its fibres, however, greatly exceeds those of the last-mentioned vegetable substances; and indeed, nearly approaches the tenacity of silk. Of this plant there are two sorts,—one becoming a red flower, the other a yellow. The leaves of both are similar to those of the common flax plant, but the flowers are smaller, and the clusters more numerous. The Zealanders obtain the flax from them by very simple and expeditious means. The fibres are beautifully fine, and white, shining like silk; the cordage made from it was found by our navigators to be very much stronger than any thing we could produce with hemp. With the view of introducing the growth of so valuable a plant in this country, Captain Ferneaux brought over some of the seeds, which were sown in Kew Gardens, by order of his late Majesty, but unfortunately failed. Subsequent to this period, the culture has been very successfully pursued by our settlers in New South Wales. We are indebted to Mr. Wm. Salisbury, of Brompton, for the discovery of this identical plant, growing indigenously in the south of Ireland, where it flourishes luxuriously. This discovery will probably prove, ultimately, of the utmost importance to Ireland, where the poor may be profitably employed, both in the culture and subsequent manufacture. Mr. Salisbury observes, that plants of three years old, will, on an average, yield thirty leaves, besides a very considerable increase of off-sets; which leaves being cut

down, at the time of clearing the quarters in the autumn, are found to spring up again in the following summer.

Respecting the produce, the same gentleman states, "Six leaves have produced me one ounce of fibres, when scutched perfectly clean and dry; at which, an acre of land planted with this crop, at three feet distance from plant to plant, will yield rather more than sixteen hundred weight per acre, which is a very great produce compared with that of hemp or flax. New Zealand flax may be scutched with little labour or trouble, and may be performed by persons in common. The leaves should be cut when full grown, and macerated for a few days in stagnant water, and then passed under a roller machine properly weighted; by this process the fibres become separated, and if washed in a running stream, will instantly become white. When the fibres are thus scutched clean and dry, any kind of friction will cause them to divide into any degree of fineness in the *harle*, so far even, as to cottonize; whereby it is fitted to all the purposes to which hemp and flax are adapted."

This plant is, at present, under cultivation in several parts of England and Wales. It will grow in either a moist or a dry soil; on a hill, or in a valley, but most luxuriously where there is an abundance of moisture.

New Zealand flax has at length become one of our established manufactures, and is now wrought into various articles of commerce; every improvement, therefore, in its preparation, that will economize the process, and extend its useful applications, is well deserving of record. Accordingly, we subjoin an account of the patent granted to Mr. J. Holt, jun. of Whitby, in Yorkshire, designed with those views.

In the manufacture of tarred cordage, the chief obstacle to the employment of that strong fibrous vegetable material, known by the term of New Zealand flax, (but which also comes from Manilla, and other parts of the East,) has been the apparent impossibility of making the fibres absorb or unite with the preservative fluid. In consequence, the chief use of the New Zealand flax has been confined to the preparation of white cordage. The patentee informs us in his specification, that he has discovered that the ultimate fibres of the flax are combined and enclosed by a coating of adhesive matter, which requires the application of some chemical solvent to set the fibres at liberty, and adapt them to the reception of tar; and the solvent which effects this object completely and economically, he finds to be a weak solution of potash of soda. His process is as follows:—

The flax having been heckled and spun into yarn in the usual manner, is in a suitable state for the chemical procedure; which consists in immersing it in a solution of potash or soda, in the proportion of half an ounce of alkali to a gallon of water, which may be either hot or cold. When the flax has been thus submitted to the action of the alkali for forty-eight hours, it is to be taken out, wrung, and hung up to dry, either in the air or in a stove. When dried, the flax will be found adapted to imbibe the tar as readily, and hold it as firmly, as the hemp in ordinary use; in performing which process, and all that may be subsequent, the rope manufacturer need make no variation from his accustomed proceedings. There is likewise included in Mr. Holt's patent, some improved mechanical apparatus for depriving the New Zealand flax of the bark and skin with which it is found combined in the commercial state. A kind of grating, made either of iron or wood, is provided, consisting of a range of parallel bars, the whole forming a right-angled parallelogram, having its two opposite longest sides inclosed by vertical boards. The bars in their transverse section are tapered, with their narrow ends or sides placed upwards in this frame; but another similar frame of bars, which is made to fit and pass over the former, has its bars with the narrow ends or sides downwards; which arrangement gives the respective frames of bars a tendency to interlock in the same manner as toothed wheels; and, therefore, when the raw flax is spread upon the lower frame of parallel bars, and the upper frame duly loaded, is laid over the flax, and passed backwards and forwards, a powerful and uniform rubbing action is produced upon the flax, which opens the fibres, while it separates the bark and other *extraneous matter*, which falls through the bar of the lower fixed

The carbonate of zinc, which is employed as a white pigment, is manufactured by pouring into a solution of zinc, in sulphuric acid, a solution of carbonate of ammonia, and afterwards washing and drying the precipitate. The next important use of zinc is in the fabrication of those useful and beautiful alloys with copper, called brass, prince's metal, &c. See ALLOY, COPPER, BRASS, &c.

Blende is the native sulphuret of zinc: the two substances are, however difficult to combine artificially. The diluted sulphuric acid dissolves zinc, giving out much heat to the solvent, while hydrogen escapes. An undissolved residue is left, which Proast says, is a mixture of arsenic, lead, and copper. The white vitriol, or white copperas, as it is usually termed, is crystallized rapidly, resembling loaf sugar. Sulphurous acid also dissolves zinc, sulphuretted hydrogen being evolved. Diluted nitric acid rapidly dissolves zinc, producing much heat with the extrication of nitrous gas. Muriatic acid operates violently upon zinc, disengaging much hydrogen. The phosphoric, fluoric, carbonic, acetic, succinic, benzoic, oxalic, tartaric, citric, and other acids, operate upon zinc, with various energy. The zinc is precipitated from its acid solutions, by means of the alkalies and soluble earths; the former re-dissolving the metal, if they be in excess. Most of the alloys or metallic combinations with zinc, have already been noticed under other heads.

ZIRCONIA. A metallic substance, discovered in the jarzon of Ceylon, by Klaproth, in 1789. It unites with the acids, is insoluble in the pure alkalies but soluble in alkaline carbonates. It does not melt before the blowpipe, but emits a yellow phosphoric light. Strongly heated for several hours in a crucible, it undergoes a species of fusion; having then some resemblance to porcelain, strikes fire with steel, scratches glass, and has a specific gravity of 4.3.

END OF VOL. II. ENGINEER'S AND MECHANIC'S ENCYCLOPÆDIA.

R. CLAY, PRINTER, BREAD-STREET-HILL.